WCAP-16465-NP
Revision 0

September 2006

Pressurized Water Reactor Owners Group Standard RCS Leakage Action Levels and Response Guidelines for Pressurized Water Reactors

Westinghouse

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Standard RCS Leakage Action Levels
and Response Guidelines for
Pressurized Water Reactors

Prepared for
Pressurized Water Reactor Owners Group
Developed under PWROG Program
PA-OSC-0218
September 2006

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PWR Owners Group
Member Participation* for Project / Task PA-OSC-0218 (Reference 1)

Utility Member	Plant Site(s)	Participant Yes	No
AmerenUE	Callaway (W)	✓	
American Electric Power	D.C. Cook 1&2 (W)	✓	
Arizona Public Service	Palo Verde Unit 1, 2, & 3 (CE)	✓	
Constellation Energy Group	Calvert Cliffs 1 & 2 (CE)	✓	
Constellation Energy Group	Ginna (W)	✓	
Dominion Connecticut	Millstone 2 (CE)	✓	
Dominion Connecticut	Millstone 3 (W)	✓	
Dominion Kewaunee	Kewaunee (W)	✓	
Dominion VA	North Anna 1 & 2, Surry 1 & 2 (W)	✓	
Duke Energy	Catawba 1 & 2, McGuire 1 & 2 (W), Oconee 1, 2, 3 (B&W)	✓	
Entergy Nuclear Northeast	Indian Point 2 & 3 (W)	✓	
Entergy Operations South	Arkansas 2, Waterford 3 (CE), Arkansas 1 (B&W)	✓	
Exelon Generation Co. LLC	Braidwood 1 & 2, Byron 1 & 2 (W), TMI 1 (B&W)	✓	
First Energy Nuclear Operating Co	Beaver Valley 1 & 2 (W), Davis-Besse (B&W)	✓	
Florida Power & Light Group	St. Lucie 1 & 2 (CE)	✓	
Florida Power & Light Group	Turkey Point 3 & 4, Seabrook (W)	✓	
Nuclear Management Company	Prairie Island 1&2, Pt. Beach 1&2 (W)	✓	
Nuclear Management Company	Palisades (CE)	✓	
Omaha Public Power District	Fort Calhoun (CE)	✓	
Pacific Gas & Electric	Diablo Canyon 1 & 2 (W)	✓	
Progress Energy	Robinson 2, Shearon Harris (W), Crystal River 3 (B&W)	✓	
PSEG - Nuclear	Salem 1 & 2 (W)	✓	
Southern California Edison	SONGS 2 & 3 (CE)	✓	
South Carolina Electric & Gas	V.C. Summer (W)	✓	
So. Texas Project Nuclear Operating Co.	South Texas Project 1 & 2 (W)	✓	
Southern Nuclear Operating Co.	Farley 1 & 2, Vogtle 1 & 2 (W)	✓	
Tennessee Valley Authority	Sequoyah 1 & 2, Watts Bar (W)	✓	
TXU Power	Comanche Peak 1 & 2 (W)	✓	
Wolf Creek Nuclear Operating Co.	Wolf Creek (W)	✓	

* Project participants as of the date the final deliverable was completed. On occasion, additional members will join a project. Please contact the PWR Owners Group Program Management Office to verify participation before sending this document to participants not listed above.

PWR Owners Group
International Member Participation* for Project / Task PA-OSC-0218 (Reference 1)

Utility Member	Plant Site(s)	Participant	
		Yes	No
British Energy	Sizewell B	✓	
Electrabel (Belgian Utilities)	Doel 1, 2 & 4, Tihange 1 & 3	✓	
Kansai Electric Co., LTD	Mihama 1, Ohi 1 & 2, Takahama 1 (W)	✓	
Korea Hydro & Nuclear Power Corp.	Kori 1, 2, 3 & 4 Yonggwang 1 & 2 (W)	✓	
Korea Hydro & Nuclear Power Corp.	Yonggwang 3, 4, 5 & 6 Ulchin 3, 4 , 5 & 6(CE)	✓	
Nuklearna Electrarna KRSKO	Krsko (W)	✓	
Nordostschweizerische Kraftwerke AG (NOK)	Beznau 1 & 2 (W)	✓	
Ringhals AB	Ringhals 2, 3 & 4 (W)	✓	
Spanish Utilities	Asco 1 & 2, Vandellos 2, Almaraz 1 & 2 (W)	✓	
Taiwan Power Co.	Maanshan 1 & 2 (W)	✓	
Electricite de France	54 Units	✓	
* This is a list of participants in this project as of the date the final deliverable was completed.. On occasion, additional members will join a project. Please contact the PWR Owners Group Program Management Office to verify participation before sending documents to participants not listed above.			

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List of Acronyms

Acronym	Description
AOP	Abnormal Operating Procedure
CDF	Cumulative probability Distribution Function
CE	Combustion Engineering
CTMT	Containment
CVS	Chemical and Volume Control System(CVCS, CE design)
ECCS	Emergency Core Cooling System
EOPs	Emergency Operating Procedures
FSAR	Final Safety Analysis Report
GPD	gallons per day
GPM	gallons per minute
HP	High Pressure
ILR	Identified leak rate (gpm)
LBB	Leak Before Break
LCO	Limiting Condition for Operation
LOCA	Loss of Coolant Accident
MP3	Millstone Point Unit 3
NP	Non Proprietary
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
OE	Operating Experience
PI	Performance Indicator
PIG	Particulate, Iodine and Gaseous (when referring to radiation monitors)
PIV	Pressure Isolation Valve
PRT	Pressurizer Relief Tank(Quench Tank, CE design)
PWR	Pressurized Water Reactor
PWROG	Westinghouse Pressurized Water Reactor Owners Group
PZR	Pressurizer
RCDT	Reactor Coolant Drain Tank (Reactor Drain Tank, CE design)
RCP	Reactor Coolant Pump
RCPB	Reactor Coolant Pressure Boundary
RCS	Reactor Coolant System
RCWV	Reactor Coolant Water Volume
RDT	Reactor Coolant Drain Tank
RG	Regulatory Guide
RHR	Residual Heat Removal
RMS	Radiation Monitoring System
RTD	Resistance Temperature Detector
SDC	Shutdown Cooling

SG	Steam Generator
SGTR	Steam Generator Tube Rupture
SI	Safety Injection
SLB	Steam Line Break
STDEV	Standard Deviation
Tave	RCS average temperature: (Thot + Tcold)/2
Tcold	RCS cold leg temperature
Thot	RCS hot leg temperature
TLR	Total Leak Rate (ILR + ULR) (gpm)
TS	Technical Specification
ULR	Unidentified Leak Rate (gpm)
UTL	Upper Tolerance Limit
VCT	Volume Control Tank
WEC	Westinghouse Electric Company

RCS Leakage Guidelines

1 EXECUTIVE SUMMARY

RCS leakage is a direct indicator of Reactor Coolant Pressure Boundary integrity. NRC Inspection Manual, IMC 2215, Appendix D (Reference 13) requires that licensees closely monitor RCS leakage and take progressive and proportional corrective actions for adverse leak rate trends. The purpose of this document is to provide standard action levels and response guidelines consistent with the intent of NRC Inspection Manual, IMC 2215, Appendix D (Reference 13). The contents of this document are guidelines consisting of the following:

1. Recommendations which can be used to develop or augment existing station-specific RCS Leakage Monitoring Programs and associated administrative procedures,
2. Standard action levels,
3. Standard basis for all action levels,
4. Guidelines which are at least as restrictive as current regulatory guidelines.
5. Action levels which are consistent with the Standard PWROG RCS Leak Rate Calculation Guidelines (Reference 2).

Statistical Approach

The PWROG guidelines take a statistical approach similar to NRC IMC 2215, Appendix D (Reference 13) by establishing a quarterly baseline dataset of valid unidentified RCS leak rate results. Statistical values for the baseline mean (μ) and standard deviation (σ) are computed and used to determine nominal limits and progressive action levels.

Standard Action Levels

As time moves forward each new RCS leak rate result is compared to the plant specific nominal limits and the appropriate action is taken. The standard action levels are:

1. Absolute Unidentified Leak Rate in gpm.

2. Deviation from the baseline mean in gpm.

3. Total integrated unidentified Leakage in gallons.

Detailed instructions and bases for the standard Action Levels are contained in the body of the guidelines.

2   PURPOSE

Develop standard action levels and response guidelines that address increasing unidentified Reactor Coolant System (RCS) leakage less than Technical Specification (TS) limits. The guidelines may be used by Pressurized Water Reactor (PWROG) members to standardize and enhance plant specific RCS leakage response procedures by providing:

1. Recommendations which can be used to develop or augment existing station-specific RCS Leakage Monitoring Programs and associated administrative procedures,

2. Standard action levels,

3. Standard basis for all action levels,

4. Guidelines which are at least as restrictive as current regulatory guidelines.

5. Action levels which are consistent with the Standard PWROG RCS Leak Rate Calculation Guidelines (Reference 2).

3   PRECAUTIONS AND LIMITATIONS

1. This guideline is applicable to all PWRs.

2. This guideline applies to monitoring and identifying changes in unidentified RCS leakage at levels that are well below Operational leakage limits established by Technical Specifications.

3. This guideline does not provide recommendations for operation during Abnormal or Emergency plant conditions;

    a. RCS leakage in excess of the total capacity of the charging pumps is addressed by Emergency Operating Procedures (EOPs) for a Loss of Coolant Accident (LOCA) or a Steam Generator Tube Rupture (SGTR).

    b. RCS leakage in excess of Technical Specification limits and within the capacity of the charging pumps is addressed by the Abnormal Operating Procedure (AOP) for excessive RCS leakage or steam generator tube leakage.

4. This guideline is applicable to Modes 1 – 4.

5. This guideline does not address standardization of RCS leak detection action levels associated with atmospheric radiation monitors (installed or portable) due to plant specific differences in equipment, design and licensing bases. Radiation detector sensitivity and Radiation Monitoring System (RMS) alarm setpoints are fuel cycle dependent and therefore associated action levels are site specific.

6. This guideline does not address a collective significance determination for long term combined indications of low level leakage. Collective Significance Determinations have previously been addressed by INPO and NEI.

4 DEFINITIONS

When used in the context of this report, the terms below are defined as described.

Term	Definition
Exceedence	A valid unidentified leak rate measurement that exceeds the baseline mean. Discussion: Typically exceedences are measured with respect to the median rather than the mean. However, for "near normal" distributions, the median and the mean are approximately equal.
Historical Baseline	The leak rate historical baseline is the mean and standard deviation value based on one operating quarter (such as JUL - SEP). The historical baseline should be recalculated at the end of each quarter for use in the next quarter.
Kurtosis	The kurtosis is a measure of the relative peakedness of the probability distribution. All normal distributions have a (relative) kurtosis of +3.0. A distribution which is flatter than the normal (i.e., the uniform distribution) has a smaller relative kurtosis and a distribution which is more peaked than the normal has a higher relative kurtosis. The relative kurtosis is always positive. Excel and most textbooks quote the kurtosis value as a "normalized" value (relative to the normal distribution value of +3.0). Therefore the "normalized" kurtosis of a normal distribution in Excel is quoted as +0.0.

Leak Before Break (LBB)	LBB is an analysis procedure with a limited scope of applicability and requires NRC review and approval. The concept of LBB implies that any crack or defect which develops in a component will grow to a through-wall configuration, and can be detectable by plant monitoring systems before reaching a size that would significantly reduce margins to component rupture. A licensee may credit LBB analysis methods only in conjunction with the establishment of reliable and comprehensive means to detect primary system leaks of the relevant size. (See References 9 and 10)
Leak Rate Measurement Standard (gpm)	Reactor Coolant System leakage should be reported as gallons per minute (gpm) to the nearest one-hundredth of gpm and normalized to pure water conditions at 70°F and 14.7 psia. Example: 0.10 gpm RCS leak rate calculations should use the following standard NIST/ASME (Reference 8) properties of water for reporting leakage: Quality: subcooled liquid Temperature: 70°F Pressure: 14.7 psia Specific Volume: 0.0160510 ft^3/lbm Density: 62.3013 lbm/ft^3 Gallons/Ft^3 7.4805 gal/ft^3
LEAKAGE Type: Gross	Gross LEAKAGE is the sum of all leakage from the RCS control volume (*see def.*) during the leak rate test time interval, ΔTime.

LEAKAGE Type: IDENTIFIED	1. LEAKAGE inside containment (except Reactor Coolant Pump (RCP) seal water injection or leakoff) into closed systems, such as pump seals or valve packing leaks that are captured and conducted to collection systems; sump or collecting tank, 2. LEAKAGE into the containment atmosphere from sources that are both specifically located and known either not to interfere with the operation of Technical Specification Leakage Detection Systems or not to be pressure boundary LEAKAGE, or 3. LEAKAGE through a Steam Generator (SG) to the Secondary.
LEAKAGE Type: PRESSURE BOUNDARY	LEAKAGE (except SG LEAKAGE) through a nonisolable fault in an RCS component body, pipe wall, or vessel wall.
LEAKAGE Type: Steam Generator	LEAKAGE from the RCS into the secondary side of the steam generators. Steam generator LEAKAGE includes LEAKAGE through all steam generators.
LEAKAGE Type: UNIDENTIFIED	All LEAKAGE inside containment (except RCP seal water injection or leakoff) that is not identified LEAKAGE.
LEAKAGE Type: Other Known RCS Leakage	Other Known RCS LEAKAGE is the sum of all leakage that is both known and documented, and not accounted for in RCDT LEAKAGE, PRT LEAKAGE, or Steam Generator LEAKAGE. Other Known LEAKAGE may include: • Documented Reactor Coolant Pressure Isolation Valve (PIV) Leakage (*see def.*) • Documented fitting or gasket leaks from the RCPB that are collected and measured

LEAKAGE Type: Non-RCPB (Non-Reactor Coolant Pressure Boundary Leakage)	Non-RCPB LEAKAGE is the sum of leakage that impacts the reactor coolant system gross leakage calculation but occurs outside the RCPB and therefore should not be included in IDENTIFIED LEAKAGE or UNIDENTIFIED LEAKAGE. In order to account for Non-RCPB LEAKAGE it must be known to exist at the time of the leak rate calculation and documented. An example of Non-RCPB LEAKAGE may include: • Charging pump packing leakage (known and documented) • Charging pump relief valve leakage (known and documented)
Leakage Investigation Plan	An approved RCS leakage response strategy including implementing procedures and action levels.
Limit of Detectability	The smallest unidentified leak rate or changes in leak rate that can almost always be detected in a given period of time using a given "alarm" function. Discussion: The term "almost always" means detected at a 95% probability and 95% confidence level (i.e., "95/95"). The term "95/95" means that we are 95% confident that at least 95% of the time a leak of this size will be detected using a given alarm function.
Mean (μ)	In ordinary English, the mean is the "average," or more correctly called the arithmetic mean. Discussion: See Section 11.2.2 of Reference 2 regarding the difference between the population mean and the sample mean.

Median	The median of a set of values is that "midpoint" value which is greater than ½ of the values and less than the remaining ½ of the values. If the number of points is even, the median is usually defined as the average of the two "innermost" values. Discussion: The median is often a more meaningful descriptor of the data than the mean when the data is "skewed". For example, in a business with 101 employees where the CEO earns $1,000,000 per year and the other 100 employees all earn $25,000 per year; the median income is $25,000 whereas the average income is $34,653. Only one employee is above average and no employees are within 38% of the average.
Outlier Screening	There are two types of outlier screening used herein. The preferred method is "extrinsic screening" in which existing known baseline mean and standard deviation values are used to screen a "new data point" by calculating its zscore value (i.e., how many standard deviations from the mean the new data point is). The term extrinsic refers to the fact that the new data point has not been used to calculate the baseline parameters. A second method, "intrinsic screening", refers to outlier screening of a stand alone set of data. In this case, outliers can bias the sample mean and standard deviation so significantly that the standard zscore formula is not useful.
Reactor Coolant Pressure Boundary (RCPB)	The Reactor Coolant Pressure Boundary (RCPB) consists of all those pressure-containing components which are part of the reactor coolant system or which are connected to the reactor coolant system, up to and including: (i) The outermost containment isolation valve in system piping which penetrates primary reactor containment. (ii) The second of two valves normally closed during normal reactor operation in system piping which does not penetrate primary reactor containment, (iii) The reactor coolant system safety and relief valves.

Reactor Coolant System (RCS) Control Volume	The RCS Control Volume includes: • Reactor Coolant Water Volume (*see def.*), • Pressurizer, and • Volume Control Tank. Gross leakage is calculated by measuring the change in level, temperature and pressure conditions in each segment of the RCS Control Volume.
Reactor Coolant Water Volume (RCWV)	The Reactor Coolant Water Volume (RCWV) is that portion of the Reactor Coolant System where the effective bulk temperature is represented by Tave. This includes the reactor coolant liquid mass contained within: • Hot leg piping, • Cold leg piping, • Reactor vessel, and • Steam generators.
Skewness	The skewness is a measure of the lack of symmetry in a probability distribution. The normal distribution has a skewness of +0.0. Distributions with excessive left hand tails have negative skewness values and those with excessive right hand tails have positive skewness.
Standard Deviation (σ)	The standard deviation is a measure of the degree of dispersion of the data from the mean value. Stated another way, the standard deviation is simply the "average" or "expected" variation around an average (i.e., square all individual deviations around the average, divide by 'N', then take the square root. You then have the 'root' of the mean squared deviation in a very simple sense the "average" or expected variation around the average). Discussion: See Section 11.2.2 of Reference 2 regarding the difference between the population standard deviation and the sample standard deviation.

Statistical Independence	Item 6 of Section 11.12 and Figures D-30 and D-31 of Appendix D of WCAP-16423-NP describe what is meant by "statistical independence". Roughly speaking, the issue was raised herein because all of the simulations and related work were based on "statistical independence" in that each simulated daily observation was based on an independent sample of a normally distributed random number. So, knowing "today's value" gives no hint regarding "tomorrow's value". However, some members were using an "ending value" for one interval as the "starting value" for the next interval and, as a consequence, successive observations were not independent. That is, an "ending" RCS inventory value which is too high due to random errors reduces the leak rate estimate for the current sample and is expected to result in an increased leak rate estimate for the next time interval when the high "ending" inventory is used as a "starting" inventory. The standard 2 hour mid-shift snapshot values are statistically independent since they are recorded at disjoint two hour intervals on different days.
Statistically Valid Result	The term "statistically valid" refers to the results of the F and two-sample t-test for consecutive Quarters of operating ULR data. That is, the current quarter's data and the previous quarter's data should be screened with the (Excel) F-test to demonstrate that the standard deviations for the two quarters are not significantly different and then the t-test to demonstrate that the means for the two quarters are not significantly different. Failing either the F test or the t-test requires some investigation since either case implies that the process has changed.
Statistically Significant Result	The term "statistically significant" means some observation or set of observations is "abnormal" enough that you should be aware of it and do something.
T average (Tave)	RCS Tave is defined as (Thot+Tcold)/2.

Zscore	The "zscore" is a shorthand way of describing how many standard deviations a given data point is from the mean. The "zscore" is calculated by subtracting the mean from the data point and dividing the result by the standard deviation. Therefore a data point which is 3 standard deviations above the mean will have a zscore of +3. <u>Discussion:</u> Outliers can have a significant effect on the mean and standard deviation of a data set. As a result, there are alternative definitions of "zscore" which are less sensitive to outliers than the mean and standard deviation.

5   ACTION LEVELS AND RESPONSE GUIDANCE

5.1   Baseline Mean and Standard Deviation

The baseline parameters for unidentified RCS leakage are the mean and standard deviation values based on one operating quarter (every calendar quarter, approximately every 90 days). The mean is obtained by averaging the valid leak rate values within a calendar quarter. (Note that valid negative leak rate values should be retained as described in Section 11.8 of Reference 2. Also see Appendix I of Reference 2 ("Comment on WCAP-16465-NP, Page 18" regarding this issue.) The standard deviation is simply the "average" or "expected" variation of data around the mean.

The mean value (μ) and the standard deviation (σ) are defined by the following equations:

$$\mu = (x1 + x2 + \ldots + xn)/n$$

$$\sigma = \sqrt{\frac{\sum(x_i - \mu)^2}{n}}$$

assuming the unidentified leakage rate, x, is a random variable which has a mean value, μ, and a standard deviation, σ.

Section 5.2.2 imposes administrative control limits on the allowed numerical values of the baseline mean and standard deviation.

5.1.1   Uses of the Baseline Mean and Standard Deviation

During normal power operations, all valid daily leak rate results are compared to the baseline to determine if RCS leakage has increased from the previous day or if the mean is shifting to a higher value relative to the baseline. Various combinations of consecutive results above the mean, numbers of standard deviations from mean and sample period are used to initiate various levels of operator response.

It is also recommended that weekly, monthly and quarterly 'rolling' averages be recorded along with the observed number of consecutive exceedences (i.e. daily average values which exceed one baseline mean). Comparing the rolling average to the mean can be useful in detecting small changes in the unidentified leak rate.

Additional guidance to ensure data integrity can be found in Reference 2. See also the peer review comment (i.e., "Comments on WCAP-16465-NP, Page 19") in Appendix I of Reference 2. Reference 2 recommendations are summarized in condensed form below:

1. The Quarterly data for the current quarter should be screened using the "F-test" and "two-sample t-test" described in Section 11.4 and Appendix G of Reference 2 before the

associated mean and standard deviation are used in the next Quarter. The results should be recorded for future use. Failing the "two-sample-t test" may indicate a "creeping" mean.

2. The daily ULR data should be visually examined and screened for outliers.

3. The Quarterly data should be tested for normality. The result should be recorded.

4. Observed "runs" of length 5 and 7 above the baseline mean should be carefully examined to see if there is any indication that an increase in the mean leak rate has occurred.

5. "Weekly rolling average" and "weekly average" plots and "Monthly rolling average" and "monthly average" plots should be maintained.

6. The number of consecutive exceedences for each week, month and Quarter should be recorded. In addition, the single largest observation in each week, month and Quarter should be recorded.

5.1.2   When and How to establish a new Baseline

In general, it is recommended that a new baseline be calculated at the end of each quarter for use in the next quarter, after startup following each refueling outage, and after performing maintenance activities on the RCS or connected systems. Before implementing the new baseline, compare it to the previous baseline to ensure that it is statistically valid.

It is the responsibility of each plant to maintain a valid baseline and establish rules for changing it. The Baseline should not be arbitrarily increased or changed in such a way as to "mask" an actual slow increase in leak rate. Any change in the RCS leak rate that may suggest changing the Baseline (particularly in the upward direction) should not be performed without first understanding and identifying what caused the change.

1. Maintenance or operations activities – When the gross RCS leak rate is reduced (or increased) due to specific maintenance or operations activities, a new baseline should be developed. These activities may include repairing leaking valve(s), switching operating charging pumps, or other similar activities which may have an influence on the RCS leak rate. Non-RCPB LEAKAGE, e.g. charging pump leakage, impacts the reactor coolant system gross LEAKAGE, but it occurs outside the RCPB. Therefore, it is not included in IDENTIFIED LEAKAGE or UNIDENTIFIED LEAKAGE. A change in gross leakage immediately following a change in operating charging pumps should be investigated and the Non-RCPB LEAKAGE term in the unidentified leak rate calculation adjusted accordingly.

2. Following restart from a refueling outage – A new baseline is required when starting up from a refueling outage. Typically, after plant heat-up to Mode 3, a containment walk down is performed to verify that there is no PRESSURE BOUNDARY LEAKAGE. After conditions stabilize (approximately 12 hours), periodic RCS leak rate calculations

are initiated as required by technical specifications. RCS leak rate results for the first week to ten days may not be accurate. It takes time for equipment packing and gaskets to swell and for the leak rate to stabilize. Therefore, during for the first seven (7) days after a refueling outage, the baseline μ and σ from the quarter just prior to the outage should be used for action level purposes. Thereafter, calculate a 7 day baseline value, a 14 day baseline, a 21 day baseline value and then a 30 day baseline value each month until the 1st quarter is completed.

Except for the conditions listed above, there should be no other initiating events requiring a baseline change. If the RCS leak rate increases or decreases, then the action level and response guidance should be used to initiate mitigating actions if an Action Level is exceeded

5.2   Standard Action Levels

The methodology for calculating unidentified RCS leak rate is provided in WCAP-16423-NP (Reference 2). The standard action levels defined in this section are associated with calculated unidentified RCS leak rate results only. Additional background is provided in Reference 2. The standard action levels in this guideline were developed with an awareness of the NRC Inspector Guidelines (Reference 13), but generally exceed the NRC Inspection guidelines.

Primary Leakage Parameters based on the results of the inventory balance:

- Rolling average of daily unidentified RCS Leak values (Unit = gpm)

- Baseline mean (μ) (Unit = gpm)

- Standard deviation (σ) (Unit = gpm)

- Total Integrated Unidentified Leakage (Unit = gallons)

The standard action levels:
1. Absolute Unidentified Leak Rate in gpm
2. Deviation from the baseline mean in gpm
3. Total integrated unidentified Leakage in gallons

5.2.1   Absolute Unidentified Leak Rate Action Levels

The Absolute Unidentified Leak Rate Action Levels in gpm are:

1. One seven (7) day rolling average of daily Unidentified RCS leak rates > 0.1 gpm.

2. Two consecutive daily Unidentified RCS leak rates > 0.15 gpm.

3. One daily Unidentified RCS leak rate > 0.3 gpm.

The Action Level of 0.1 gpm is 1/10th of the current TS Limit for unidentified leakage.

The 7 day rolling average should be calculated by setting any negative value to 0.0 prior to performing the average. Any missing daily average value (i.e., a daily average value is the average of all valid measurements performed on a given calendar day) should be set to the value recorded for the previous day. The daily rolling average is calculated by adding the current daily value and removing the last daily value as described in Section 5.2.3.

If a daily average value exceeding 0.15 gpm is observed, a second daily average value should be measured the following day. That is, a "missing value" for the second day would be based on the previous day's value which would then automatically result in two consecutive values above 0.15 gpm. (See Customer Comment #161 in Appendix H of Reference 2.)

The primary purpose of the Absolute Unidentified Leak Rate Action Level is to ensure that a slow, creeping small leak does not contaminate the Baseline mean value as the operating cycle progresses.

Note that a typical standard deviation is about 0.055 gpm. (This is the value used in the simulation documented in Section 11 of Reference 2.). Therefore, applying the "two-sample-t test" to successive 30 day periods (per Reference 2) could "pass" if the mean was creeping up by a little less than 0.43 x 0.055 gpm per month or 0.024 gpm per month. After 24 months (longest current operating cycle), this "creep" amounts to an increase in the Baseline value of 24 x 0.024 or 0.6 gpm. The equivalent value for 90 day periods is 0.25 x .055 x {24 months/3 months} = 0.11 gpm. As a consequence, it is possible that a Baseline mean that was about 0.0 near BOC could "creep" at an undetected rate of about 0.014 gpm every quarter and wind up in excess of 0.1 gpm ULR (1/10th of the Tech Spec unidentified leakage limit) near EOC. In our judgment, if two successive sets of quarterly data just passed the "2 sample t-test", there is only a small probability that the three Action Levels in the current NRC Appendix D Guidelines would be actuated. The 7 day absolute ULR Action Level of 0.1 gpm guards against a creeping mean from developing as the cycle progresses.

A secondary purpose of this Action Level is to provide an early warning that the "short term" Action Level for total integrated unidentified leakage is likely to be violated if no action is taken. That is, 30 days of operation with a daily average of 0.1 gpm ULR will nearly exceed the 5000 gallon total integrated unidentified leakage Action Level (refer to Section 5.2.3).

The Action Levels on two consecutive observations and one single observation should be considered a "belt & suspenders" approach to the current NRC Appendix D Guidelines (Reference 13). That is, these Action Levels are similar to Action Levels II & III in the current Guidelines and probably all would be invoked by such large observations.

Also see the peer review comment (i.e., "Comments on WCAP-16465-NP, Page 21") regarding the treatment of negative leak rate values in Appendix I of Reference 2.

5.2.2   Deviation from the Baseline Mean Action Levels

Once a quarter use the mean value (μ) and the standard deviation (σ) from the previous quarter (three months) to calculate action levels based on a deviation from mean. The action levels are:

1. Nine (9) consecutive daily Unidentified RCS leak rates > baseline mean [μ].

2. Two (2) of three (3) consecutive daily Unidentified RCS leak rates > [$\mu + 2\sigma$].

3. One (1) daily Unidentified RCS leak rate > [$\mu + 3\sigma$].

Action Level 1 is important because it is most likely to be encountered for small leaks. The value of nine (9) consecutive measurements was chosen because it equates to the length of a "Statistically Significant Run." That is, a run of 9 consecutive values above the mean should be considered statistically significant. "Run" measurements such as this which are adapted from the statistical quality control of production processes are designed to pick up a sudden, sustained shift in the process generating the data. Section 5.3 addresses evolving trends.

Action Level 2 is triggered when 2 of 3 consecutive daily measurements exceed the baseline mean by 2 standard deviations. Action Level 3 is triggered when one daily measurement exceeds the baseline mean by 3 standard deviations. Each of these Action Levels was analyzed with the stochastic simulations performed in Reference 2, Section 11.3 and are similar to the NRC Appendix D Inspection Guidelines. A critique of NRC Appendix D is presented in Appendix F of Reference 2.

The use of the word "daily" in Section 5.2.2 should be interpreted as "periodic" if a Utility performs ULR measurements on less than a daily basis. For example, if one measurement is routinely scheduled to be performed every other day or once every 72 hours (the surveillance interval set by the Technical Specifications).

The following administrative limits on the allowed numerical value of the baseline standard deviation and baseline mean apply when calculating Section 5.2.2 Action Levels:

- If the baseline standard deviation is less than +0.01 gpm, use +0.01 for computing the section 5.2.2 Action Levels.

- The upper limit on the baseline standard deviation is 0.1 gpm.

- The baseline mean should be in the range -0.025 to +0.075 gpm.

Values of the baseline standard deviation greater than +0.1 gpm and baseline mean values outside the stated range should be investigated.

5.2.3   Total Integrated Unidentified Leakage Action Levels

The Total Integrated unidentified Leakage Action Levels in gallons are:

1. Short Term (30 Day) Total Integrated Unidentified Leakage > 5,000 gallons

2. Long Term (Operating Cycle) Total Integrated Unidentified RCS Leakage > 50,000 gallons

The 30 Day Total Integrated Unidentified Leakage Action Level is 5,000 gallons. This Action Level is calculated by adding the average leak rate determined for each calendar day (in gpm) then multiplied by 60 minutes/hour x 24 hours/day (1440) to a "rolling sum" over the last 29 days. That is, as each new day's value is determined, the oldest day is removed from the "rolling sum" and the new day's value is added. Note that the "rolling sum" is the same as the "rolling average" x 1440 x 30 if there are no missing daily values. To ensure that this "rolling sum" does not decrease as the sum accumulates from day 1 to day 30, any day which has a negative average leak rate should be entered as "0.0 gpm". Any missing day's value should be set to the value recorded for the previous day.

The Long Term (Operating Cycle) Total Integrated Unidentified Leakage Action Level is 50,000 gallons. This Action Level is calculated by accumulating a "rolling sum" throughout the Operating Cycle as described above. Negative daily values should be entered as "0.0 gpm". Missing daily values should be set to the value recorded for the previous day whenever the NSSS is at "hot, pressurized" conditions (Modes 1, 2 and 3). Daily values should be set to "0.0 gpm" whenever the NSSS is in cold shutdown, depressurized conditions (Modes 4, 5 and 6).

The purpose of the "short term" (30 days) Action Level is to ensure prompt action in the event that there is a significant leak rate over a short period of time. The 30 day period is coincident with the current NRC Appendix D Guidelines for revising the Baseline mean and standard deviation values. (That is, the Appendix D Baseline values are set by the last 90 days of observation and applied to the upcoming 30 days. At the end of the next 30 days, the Baseline values are updated.) The 5000 gallon Action Level is set by the observation that the Technical Specifications typically require one measurement every 72 hours with an associated ULR limit of 1 gpm. In a limiting case, where a 1 gpm leak started immediately after the 72 hour surveillance, 1 x 60 x 72 gallons or 4,320 gallons could leak prior to the next 72 hour measurement. If the leak rate was 1/10 of the Tech Spec limit (0.1 gpm), and this leak persisted for 30 days, the accumulated leakage would be: 0.1 gpm x 60 x 24 x 30 or 4,320 gallons - the same value derived above using the TS limits. As a result, restricting the 30 day Action Level to 4320 gallons is equivalent to setting the 30 day "rolling average" leak rate to 0.1 gpm or 1/10th of the TS limit. The value 4,320 was rounded up to 5,000 for ease of use.

The purpose of the "long term" Action Level (One Operating Cycle) is to ensure that the NSSS does not operate just below the "short term" Action Level for the entire cycle. In a worst case scenario (24 month Operating Cycle), this would result in a total cumulative leakage of 5,000 gallons x 24 months or 120,000 gallons. This is an excessive amount. The 50,000 gallon Action Level is based on the observation that many plants operate with daily average ULR values near

0.05 gpm (1/20th of the TS limit). This value results in a cumulative value of .05 gpm x 60 x 24 x 365 x 2 or 53,000 gallons. This value is rounded down to 50,000 for ease of use. Note: continued operation near 0.05 gpm doesn't necessarily imply that the Operating Cycle leakage will actually be near 50,000 gallons since a significant component of the 0.05 gpm may be due to spurious instrumentation and process fluctuations.

Also see the peer review comment (i.e., Comments on WCAP-16465-NP, Page 21") regarding the treatment of negative leak rate values in Appendix I of Reference 2.

5.3   Tracking and Trending Data

Each plant should have a RCS leakage monitoring program. In general the program should consist of a program description, leakage indicators, administrative procedures including action levels to respond to increasing levels of unidentified RCS leakage.

Leakage indicators, as used in the context of a leakage monitoring program, are parameters or calculated values used to detect or confirm changes in RCS leakage. They are plant specific. Following is a list of typical examples:

- Gross RCS leak rate
- Unidentified RCS leak rate

    - Absolute value(s) and rolling averages
    - Deviation from the baseline mean
    - Cumulative leakage totals

- Identified RCS leak rate
- Primary-to Secondary leak rate (addressed by separate program, Reference 3)
- VCT Level Trend
- Pressurizer Relief Tank (PRT) or Quench Tank in leakage
- Reactor Coolant Drain Tank (RDT) in leakage
- Containment Sump level or flow monitoring

    - Containment Sump pump-out Frequency

- Auxiliary Building Sump Tank in leakage
- RCP Seal Leakoff rates
- Containment Air Cooling Unit condensation flow monitoring
- Containment Atmosphere gaseous and particulate activity

    - {Containment Atmosphere Activity Equivalent Leak rate}

- Containment Atmosphere dew point (temperature and pressure)
- RCS and SI check valve seat leakage (addressed by separate program)

- Visual inspections for signs of leakage such as Boric Acid accumulation (refer to Reference 4)
- HP monitoring procedures such as area surveys and area radiation monitors

The owner of the RCS leakage monitoring program should periodically perform the following activities:

1. Track Leakage Indicators and analyze for trends.

2. Prepare an analysis summary of leakage indicator trends and make recommendations to plant management as appropriate.

3. Present the leakage analysis summary at the appropriate plant staff meeting(s).

4. Use the leakage analysis summary to create/update RCS leakage displays to increase visibility and plant awareness.

5.4   Action Level Response Guidelines

The action levels are constructed to complement each other. One type of Action Level is a check of the other. Within each type of Action Level, the triggers get progressively larger, so as to focus attention on detection of very small leaks since larger leaks will be more apparent and therefore easier to detect. The action levels are arranged into three tiers. Each tier contains at least one action level for each type so as to corroborate each other. Tier one, two and three Action Levels are designed to address progressively larger leaks.

Tier One Action levels:

IF ANY of the following Action Levels are exceeded:
1. One seven (7) day rolling average of daily Unidentified RCS leak rates > 0.1 gpm.

2. Nine (9) consecutive daily Unidentified RCS leak rates > baseline mean $[\mu]$.

Tier Two Action Levels:

IF ANY of the following Action Levels are exceeded:
1. Two consecutive daily Unidentified RCS leak rates > 0.15 gpm.

2. Two (2) of three (3) consecutive daily Unidentified RCS leak rates > $[\mu + 2\sigma]$.

3. Short Term (30 Day) Total Integrated Unidentified Leakage > 5,000 gallons.

Tier Three Action Levels:

IF ANY of the following Action Levels are exceeded:

1. One daily Unidentified RCS leak rate > 0.3 gpm.

2. One (1) daily Unidentified RCS leak rate > $[\mu + 3\sigma]$.

3. Long Term (Operating Cycle) Total Integrated Unidentified RCS Leakage > 50,000 gallons.

5.4.1 Response Guidelines for Exceeding Tier One Action Levels

1. If any Tier One Action Level is exceeded, perform the following:
    a. Confirm indication.
    b. Evaluate trend of affected parameter.
    c. Evaluate trend of associated Tier One parameters.
    d. Run confirmatory leak rate calculation.
    e. Check for abnormal trends for other leakage indicators (Refer to Section 5.3).

2. If initial indication is confirmed,
    a. Increase monitoring of leakage indicators.
    b. Initiate a Condition Report.
    c. Notify cognizant system engineer(s) to obtain their input/help.

5.4.2 Response Guidelines for Exceeding Tier Two Action Levels

If any Tier Two Action Level is exceeded, perform the following:

1. Perform Tier One response (Section 5.4.1).

2. Commence a leak investigation:
    a. Review recent plant evolutions to determine any "suspect" source(s).
    b. Evaluate changes in other leakage detection indications.
    c. Initiate outside containment walk-downs of various portions of potentially affected systems.

3. Identify the source of the increase in leakage:
    a. Check any components or flow paths recently changed or placed in service, shutdown, vented, drained, filled, etc.
    b. Check any maintenance activity that may have resulted in increasing leakage.
    c. Check any filters recently alternated or changed for leakage from their vents or drains. Inspect filter housing for gasket leakage. Check seal injection filters and reactor coolant filter for signs of leakage.

5.4.3   Response Guidelines for Exceeding Tier Three Action Levels

If any Tier Three Action Level is exceeded, perform the following:

1. Perform Tier One and Tier Two responses (Sections 5.4.1 and 5.4.2).

2. If the increased leak rate is indicated inside containment, then:

   a. Begin planning for a containment entry while carrying out other actions. Obtain proper approval for containment entry.

   b. Obtain a containment sump sample (during pump out) and analyze for activity, a larger than expected boric acid concentration and other unexpected chemicals.

   c. Evaluate other systems for indications of leakage (Component Cooling Water, Service Water, etc.)

   d. Obtain a containment atmosphere sample for indications of RCS leakage.

3. Identify source of the leak.

4. Quantify the leakage.

5. Initiate plan to correct the leak.

6. Monitor containment airborne radiation levels as well as area radiation monitors. Sample containment atmosphere for indications of RCS leakage.

7. Monitor other containment parameters (temperature, pressure, humidity, etc.).

8. Implement portions of the RCS leak investigation procedure (plant specific) to identify potential leak sources.

9. If the leak source is found and isolated or stopped, re-perform RCS leak rate calculation.

6 RCS LEAKAGE MONITORING PROGRAM OVERVIEW

Each plant should have a plant specific leakage monitoring program (refer to Reference 5). The overall goal of a RCS leakage Monitoring Program is to provide early leak detection and minimize the consequences associated with RCS leakage by:

1. Maintaining leakage of reactor coolant at the lowest attainable values.

2. Providing assurance that the plant will not be operated with RCS pressure boundary leakage.

3. Monitoring RCS leakage trends for earliest possible detection and evaluation of new or increasing RCS leakage.

4. Prompt notification of management personnel of new or increasing RCS leakage, even if the leakage is well within the Tech Spec thresholds for action.

6.1 General Elements of an Effective RCS Leakage Monitoring Program

An effective RCS leakage monitoring program should address the following general requirements:

1. At least three dissimilar, diverse and independent principal methods of monitoring coolant leakage from the RCPB to the containment, one of which is the sump level and/or sump flow monitoring.

2. The principal methods of leak detection should be capable of indicating and alarming when TS values or administrative limits are exceeded.

3. Leakage collection and measurement systems should be provided for identified sources to limit the expected leakage to the containment atmosphere to the extent practical. Leakage to the containment from identified sources should be collected or isolated so that:

    a. The flow rates from identified leaks are monitored separately from unidentified leaks.
    b. The total flow rate from identified leaks can be established and monitored.

4. Provisions shall be made to monitor systems connected to the RCPB through passive barriers for indications of Non-Reactor Coolant Pressure Boundary Leakage. This includes radioactivity monitoring and water inventory monitoring.

5. Leakage detection systems should be operable as specified in Tech Specs any time the plant is not in a cold shutdown condition.

6. Monitoring systems should be designed to maintain specified accuracy and performance features for the range of temperature, humidity and radiation levels that are expected during normal plant operations.

7. Displays and alarms for all leakage detection systems should be located in the Main Control Room. This includes displays, indications and computer functions. Capability for trend monitoring should also be provided.

7   ADDITIONAL RCS LEAKAGE MONITORING BEST PRACTICES

1. Use computerized continuously running leak rate calculations.

8   REGULATORY REQUIREMENTS AND BACKGROUND

8.1   General Regulatory Requirements associated with RCS Leakage (Reference 13)

Each plant should monitor for RCS pressure boundary leakage and unidentified leakage exceeding TS limits. To accomplish this objective, plant staff should:

1. Monitor and trend leak monitoring parameters such as the containment atmosphere particulate radioactivity instruments, the containment sump flow/level instruments, the containment atmosphere gaseous radioactivity instruments, the containment humidity instruments, and/or any plant-specific instrumentation to indicate potential RCS leakage.

2. Periodically perform an RCS inventory balance and attempt to confirm RCS unidentified leakage with alternate and diverse means, such as, changes in containment sump level or sump pumping frequency and volume.

3. Take appropriate actions in accordance with plant-specific leak rate impact or leakage investigation procedures (leakage source identification, quantification, classification, etc.) when RCS leakages are suspected. Also, re-classify unidentified leakage as identified leakage only when the leak rate has been actually quantified and identified.

4. Conduct activities to identify sources of RCS unidentified leakage. Document actions taken to identify sources of unidentified RCS leakage in the control room logs or in the corrective action program, as specified in plant administrative procedures. The leak identification plan should include actions such as system walkdowns; system surveillance and re-alignment; containment entry and visual inspections for boric acid deposits; inspection of pumps and valves for possible seal and packing leakages; inspection of pipe flanges and major welds, including instrument lines and connections; and sampling/ performing isotopic analysis of atmospheres, filter elements and sumps.

5. Trend unidentified leak rates, pay particular attention to changes in unidentified leakages and take appropriate corrective action for adverse trends. Also, trend other containment parameters such as containment sump inleakage rates, the containment air/gaseous radiation monitor indication, the containment particulate radiation monitor indication,

and the containment humidity indication to validate potential RCS unidentified or pressure boundary leakages. If significant adverse trends occur, ensure prompt corrective actions are initiated. Plants must have appropriate procedure(s) for responding to adverse RCS leakage trends. Procedures must include action steps, as unidentified leakage approaches administrative limits or technical specifications allowed values.

8.2 Standard Tech Spec Definitions for RCS Leakage

RCS operational LEAKAGE (typical for all PWRs, References 11 and 12) shall be limited to:

1. No pressure boundary LEAKAGE,

2. 1 gpm unidentified LEAKAGE,

3. 10 gpm identified LEAKAGE,

4. 1 gpm total primary to secondary LEAKAGE through all Steam Generators (SGs), and

5. 500(W)/720(CE) gallons per day primary to secondary LEAKAGE through any one SG.

RCS leakage detection instrumentation (typical for all PWRs, References 11 and 12) shall be OPERABLE:

1. One containment sump (level or discharge flow) monitor,

2. One containment atmosphere radioactivity monitor (gaseous or particulate), and

3. One containment air cooler condensate flow rate monitor.

8.3 NRC Regulatory Guide 1.45

The NRC Regulatory Guide 1.45, issued in 1973, (Reference 6) established capabilities for leak detection systems acceptable to the NRC staff. It does not define limiting conditions of operation. RG 1.45 does note, however, that Technical Specifications (TSs) that define the limiting conditions for operation for identified and unidentified leakage and address the availability of the leak detection systems are generally implemented. RG 1.45 proposes that leaks should be monitored to a sensitivity of 1 gpm or better with at least three detection methods. The leak detection system should be able to detect a 1 gpm leak in less than 1 hour, and alarms for the leak detection systems should be located in the control room. Sump level and airborne particulate radioactivity monitors are required. The third monitor could be either a condensate flow monitor or a radiation monitor. This capability has typically been provided through an airborne gaseous radioactivity monitor. Such monitors do not provide leakage rates, but have the capability of indicating an increase of 1 gpm within an hour. However, because failed fuel is much less likely to occur and primary systems have become less contaminated than was the case when RG 1.45 was issued, the threshold value for gaseous activity has been lowered

to increase leakage sensitivity. In RG 1.45, monitoring of the containment humidity, temperature, and pressure are considered indirect indications of leakage.

8.4   Bases for Operational Leakage

Components that contain or transport the coolant to or from the reactor core make up the RCS. Component joints are made by welding, bolting, rolling, or pressure loading, and valves isolate connecting systems from the RCS. During plant life, the joint and valve interfaces can produce varying amounts of reactor coolant LEAKAGE, through either normal operational wear or mechanical deterioration. The purpose of the RCS Operational LEAKAGE LCO is to limit system operation in the presence of LEAKAGE from these sources to amounts that do not compromise safety. This LCO specifies the types and amounts of LEAKAGE.

10 CFR 50, Appendix A, GDC 30 (Reference 7), requires means for detecting and, to the extent practical, identifying the source of reactor coolant LEAKAGE. Regulatory Guide 1.45 (Reference 6) describes acceptable methods for selecting leakage detection systems. The safety significance of RCS LEAKAGE varies widely depending on its source, rate, and duration. Therefore, detecting and monitoring reactor coolant LEAKAGE into the containment area is necessary. Quickly separating the identified LEAKAGE from the unidentified LEAKAGE is necessary to provide quantitative information to the operators, allowing them to take corrective action should a leak occur that is detrimental to the safety of the facility and the public.

A limited amount of leakage inside containment is expected from auxiliary systems that cannot be made 100% leak tight. Leakage from these systems should be detected, located and isolated from the containment atmosphere, if possible, to not interfere with RCS leakage detection. This LCO deals with protection of the Reactor Coolant Pressure Boundary (RCPB) from degradation and the core from inadequate cooling, in addition to preventing the accident analyses radiation release assumptions from being exceeded. The consequences of violating this Limiting Condition for Operation (LCO) include the possibility of a Loss of Coolant Accident (LOCA).

Except for primary to secondary LEAKAGE, the safety analyses do not address operational LEAKAGE. However, other operational LEAKAGE is related to the safety analyses for LOCA; the amount of leakage can affect the probability of such an event. The safety analysis for an event resulting in steam discharge to the atmosphere assumes a 1 gpm primary to secondary LEAKAGE as the initial condition.

Primary to secondary LEAKAGE is a factor in the dose releases outside containment resulting from a Steam Line Break (SLB) accident. To a lesser extent, other accidents or transients involve secondary steam release to the atmosphere, such as a Steam Generator Tube Rupture (SGTR). The leakage contaminates the secondary fluid.

The FSAR analysis for SGTR assumes the contaminated secondary fluid is only briefly released via safety valves and the majority is steamed to the condenser. The 1 gpm primary to secondary LEAKAGE is relatively inconsequential.

The SLB is more limiting for site radiation releases. The safety analysis for the SLB accident assumes 1 gpm primary to secondary LEAKAGE in one generator as an initial condition. The dose consequences resulting from the SLB accident are well within the limits defined in 10 CFR 100 or the staff approved licensing basis (i.e., a small fraction of these limits).

RCS operational LEAKAGE shall be limited to:

1. Pressure Boundary LEAKAGE

   No pressure boundary LEAKAGE is allowed, being indicative of material deterioration. LEAKAGE of this type is unacceptable as the leak itself could cause further deterioration, resulting in higher LEAKAGE. Violation of this LCO could result in continued degradation of the RCPB. LEAKAGE past seals and gaskets is not pressure boundary LEAKAGE.

2. Unidentified LEAKAGE

   One gallon per minute (gpm) of unidentified LEAKAGE is allowed as a reasonable minimum detectable amount that the containment air monitoring and containment sump level monitoring equipment can detect within a reasonable time period. Violation of this LCO could result in continued degradation of the RCPB, if the LEAKAGE is from the pressure boundary.

3. Identified LEAKAGE

   Up to 10 gpm of identified LEAKAGE is considered allowable because LEAKAGE is from known sources that do not interfere with detection of unidentified LEAKAGE and is well within the capability of the RCS Makeup System. Identified LEAKAGE includes LEAKAGE to the containment from specifically known and located sources, but does not include pressure boundary LEAKAGE or controlled Reactor Coolant Pump (RCP) seal leakoff (a normal function not considered LEAKAGE). Violation of this LCO could result in continued degradation of a component or system.

4. Primary to Secondary LEAKAGE through All Steam Generators (SGs)

   Total primary to secondary LEAKAGE amounting to 1 gpm through all SGs produces acceptable offsite doses in the SLB accident analysis. Violation of this LCO could exceed the offsite dose limits for this accident. Primary to secondary LEAKAGE must be included in the total allowable limit for identified LEAKAGE.

5. Primary to Secondary LEAKAGE through Any One SG

   The [500] gallons per day limit on one SG is based on the assumption that a single crack leaking this amount would not propagate to a SGTR under the stress conditions of a LOCA or a main steam line rupture. If leaked through many cracks, the cracks are very small, and the above assumption is conservative.

8.5 Bases for RCS Leak Detection and Monitoring Instrumentation

GDC 30 of Appendix A to 10 CFR 50 (Reference 7) requires means for detecting and, to the extent practical, identifying the location of the source of RCS LEAKAGE. Regulatory Guide 1.45 (Reference 6) describes acceptable methods for selecting leakage detection systems.

Leakage detection systems must have the capability to detect significant Reactor Coolant Pressure Boundary (RCPB) degradation as soon after occurrence as practical to minimize the potential for propagation to a gross failure. Thus, an early indication or warning signal is necessary to permit proper evaluation of all unidentified LEAKAGE.

Industry practice has shown that water flow changes of 0.5 to 1.0 gpm can be readily detected in contained volumes by monitoring changes in water level, in flow rate, or in the operating frequency of a pump. The containment sump is used to collect unidentified LEAKAGE and the air cooler condensate flow rate monitor is instrumented to alarm for increases of 0.5 to 1.0 gpm in the normal flow rates. This sensitivity is acceptable for detecting increases in unidentified LEAKAGE.

The reactor coolant contains radioactivity that, when released to the containment, can be detected by radiation monitoring instrumentation. Reactor coolant radioactivity levels will be low during initial reactor startup and for a few weeks thereafter, until activated corrosion products have been formed and fission products appear from fuel element cladding contamination or cladding defects. Instrument sensitivities of 10^{-9} μCi/cc radioactivity for particulate monitoring and of 10^{-6} μCi/cc radioactivity for gaseous monitoring are practical for these leakage detection systems. Radioactivity detection systems are included for monitoring both particulate and gaseous activities because of their sensitivities and rapid responses to RCS LEAKAGE.

An increase in humidity of the containment atmosphere would indicate release of water vapor to the containment. Dew point temperature measurements can thus be used to monitor humidity levels of the containment atmosphere as an indicator of potential RCS LEAKAGE. A 1°F increase in dew point is well within the sensitivity range of available instruments. Since the humidity level is influenced by several factors, a quantitative evaluation of an indicated leakage rate by this means may be questionable and should be compared to observed increases in liquid flow into or from the containment sump [and condensate flow from air coolers]. Humidity level monitoring is considered most useful as an indirect alarm or indication to alert the operator to a potential problem. Humidity monitors are not required by this LCO.

Air temperature and pressure monitoring methods may also be used to infer unidentified LEAKAGE to the containment. Containment temperature and pressure fluctuate slightly during plant operation, but a rise above the normally indicated range of values may indicate RCS leakage into the containment. The relevance of temperature and pressure measurements is affected by containment free volume and, for temperature, detector location. Alarm signals from these instruments can be valuable in recognizing rapid and sizable leakage to the containment. Temperature and pressure monitors are not required by this LCO.

The need to evaluate the severity of an alarm or an indication is important to the operators, and the ability to compare and verify with indications from other systems is necessary. The system response times and sensitivities are described in each plant's FSAR. Multiple instrument locations are utilized, if needed, to ensure that the transport delay time of the leakage from its source to an instrument location yields an acceptable overall response time.

The safety significance of RCS LEAKAGE varies widely depending on its source, rate and duration. Therefore, detecting and monitoring RCS LEAKAGE into the containment area is necessary. Quickly separating the identified LEAKAGE from the unidentified LEAKAGE provides quantitative information to the operators, allowing them to take corrective action should a leakage occur detrimental to the safety of the unit and the public.

One method of protecting against large RCS leakage derives from the ability of instruments to rapidly detect small leaks. This LCO requires instruments of diverse monitoring principles to be OPERABLE to provide a high degree of confidence that extremely small leaks are detected in time to allow actions to place the plant in a safe condition, when RCS LEAKAGE indicates possible RCPB degradation.

8.5.1 Alternate Requirement approved for some utilities

NRC Generic Letter 84-04 allows more relaxed criteria of 1 gpm in 4 hours, provided a plant meets all the other requirements for implementation of Leak-before-Break. Therefore some plants have an NRC SER for approval of LBB, and their basis for leak rate detection is 1 gpm in 4 hours instead of 1 gpm in 1 hour.

The relaxation in the requirements is based on the leak rate analysis for postulated cracks in the RCPB as detailed in GL 84-04. The criteria used to ensure that adequate margins against breaks includes the potential to tolerate large throughwall flaws without unstable-crack extension so that leakage detection systems can detect leaks in a timely manner during normal operating conditions. To ensure that adequate leak detection capability is in place, the following guidance is provided for those plants evaluated in GL 84-04 whose asymmetric blowdown loads (resulting from double-ended pipe breaks in the RCS piping) are not a concern:

> *"Leakage detection systems should be sufficient to provide adequate margin to detect the leakage from the postulated - circumferential throughwall flaw utilizing the guidance of Regulatory Guide 1.45, "Reactor Coolant Pressure Boundary Leakage Detection Systems," with the exception that the seismic qualification of the airborne particulate radiation monitor is not necessary. At least one leakage detection system with a sensitivity capable of detecting 1 gpm in 4 hours must be operable."*

9 REFERENCES

1. Westinghouse Owners Group Project Authorization, RCS Leakage Action Levels and Response Guidelines, No. PA-OSC-0218, Revision 0, June 2005.

2. WCAP-16423-NP, PWROG Standard Process and Methods for Calculating RCS Leak Rate for Pressurized Water Reactors.

3. EPRI TR-104788-R2, PWR Primary-To-Secondary Leak Guidelines, Revision 2, April 2000.

4. EPRI TR-104748, Boric Acid Corrosion Control Guidebook.

5. EPRI TR-114761, Establishing an Effective Fluid Leak Management Program.

6. NRC Regulatory Guide 1.45, 1973, Reactor Coolant Pressure Boundary Leak Detection Systems.

7. 10 CFR 50 Appendix A, General Design Criteria 30

8. NIST/ASME Steam Properties, Standard Reference Database 10, Version 2.11.

9. NUREG-1061, "Report of the U.S. Nuclear Regulatory Commission Piping Review Committee," U.S. Nuclear Regulatory Commission, (Vol. 1) August 1984, (Vol. 2) April 1985, (Vol. 3) November 1984, (Vol. 4) December 1984, (Vol. 5) April 1985.

10. NUREG-0800, Standard Review Plan 3.6.3, Leak-Before-Break Evaluation Procedures.

11. NUREG 1431, Revision 3, 3/31/2004, Westinghouse Standard Technical Specifications,

12. NUREG 1432, Revision 3, 3/31/2004, Combustion Engineering Standard Technical Specifications,

13. NRC Inspection Manual, IMC 2215, Appendix D,

10 APPENDICES

10.1 Review of RCS Leakage Event Operating Experience

Appendix 10.1

Review of RCS Leakage Event Operating Experience

10.1   INTRODUCTION

The purpose of this Appendix was to review leakage events that have occurred in the past to address the following question: If the standard action levels had been in use at the time of the event, is it more or less likely that the leak would have been detected sooner? After reviewing the event reports it became apparent that there was not enough historical data in the reports to perform any kind of objective analyses of the events relative to the question at hand. However, Westinghouse was able to draw some meaningful general conclusions appropriate for inclusion in this report. Westinghouse was able to come closest to analyzing application of the new guideline during actual events by looking at two recent events at member plants. These analyses are located following the INPO Operating Experience (OE) review in Section 10.5.

10.2   APPROACH AND METHODOLOGY

The INPO Operational Experience (OE) data base was used to identify all 'Reactor Coolant leakage' events between 01/01/1995 to 02/25/2005. All US Westinghouse, Babcock and Wilcox and Combustion Engineering PWRs were included in the review. The assessments and conclusions that follow are based solely on the OE information provided in the reports. No effort was made to search for additional or supplemental information.

10.3   DESCRIPTION

The data search identified one hundred seven (107) events meeting the above criteria. The list was reduced to eighty-seven (87) unique events that were reviewed and analyzed further. During the review, the following information was recorded in a spread sheet: 1) the source of the leak, 2) the OE report number, 3) the leak rate or volume (when available), 4) the operational mode at time of discovery, and 5) how the leak was discovered and 6) how the leak was confirmed. Unfortunately, if there were administrative limits or action levels in place at the time, they could not be recorded because usually this information was not included in the report.

10.4   ANALYSES

10.4.1 When leaks were discovered

Table 10.1-3 contains all events sorted by the date when the leak was discovered. Thirty-two (32) of the leaks were discovered while the plant was in mode 1 at full power, seventeen (17) were found during startup and thirty-one (31) when the plant was shutdown for refueling. The remaining events also occurred during refueling but were associated with Shutdown Cooling (SDC) system operation. These were typically drain-down events, large losses of inventory as opposed to small leaks.

Leaks discovered during refueling were discovered by observing boron deposits while carrying out the boron inspection program. The amount of boron accumulation was dependent on the size of the leak and its duration. Boron deposits varied from a few ounces to several pounds. Small leaks detected by the boron inspection program typically were not detected by other leak detection methods when the plant is operating. This is the type of leak that fits the primary objective of the standard RCS leak rate calculation guidelines and action levels. That is, to

detect very small leaks as soon as possible so as to minimize the exposure of RCS surfaces to boric acid and minimize the resultant caustic stress corrosion.

Leaks detected during mode 3 (startup), were usually detected during plant heat-up and pressurization by visual inspection during containment walk-down. Many of these leaks were caused by maintenance activities during the prior outage. The inventory balance and associated action levels were of little use in detecting these leaks since RCS conditions were not yet stabilized and the inventory balance was not believed to be reliable (if being performed). However, performing leak rate calculations during startup can provide useful information to the operator even though the quantitative results may not be very accurate. For example, Mode 3 leak rates provide a relative indication of normal vs. abnormal leakage and trending information. Also, they provide a good opportunity for the operator to observe the response of the leak rate calculation to real leaks (should any exist at startup, by comparing results before and after the leak is corrected). Also, these results can assist the operator in determining when stable RCS conditions have been achieved.

The remaining leaks were discovered mid-cycle at power. The size of these leaks ranged from a fraction of a gallon per minute to several gallons per minute. The larger leaks were not hard to detect. Usually, they were discovered by routine operator observation of tank or sump inventory trends, e.g., Volume Control Tank (VCT) level trends and charging/letdown flow mismatch. Small leaks were harder to detect. They were usually detected and confirmed over time by careful data collection, trending and analyses, using a combination of corroborative leakage indicators such as inventory balance results, containment particulate or gaseous activity, containment atmospheric conditions and chemical analyses.

10.4.2 How at power leaks were detected and/or confirmed

The focus of the standard RCS leak rate guidelines and action levels is leak detection during normal power operation. The leakage indicators most frequently mentioned in the OE reports for this category of leaks were:

- Inventory Balance
- Containment Particulate Activity
- Containment Gaseous Activity
- Visual Inspection
- Containment Atmospheric Conditions (humidity, temperature, hydrogen etc.)
- Containment Sump Inventory (level and pump out rate)
- VCT level trend
- Miss-match between Charging and Letdown
- Local Area Radiation levels

Table 10.1-2 contains a list of all mode 1 leaks sorted by 'How the leak was detected'. Table 10.1-3 is the same list of leakage events sorted by leakage source. Of these about half of the reports stated that the inventory balance was used to detect the leak, either to confirm it or quantify it. The leak rates at the time of discovery for this group ranged from 0.07 gpm to as high as 10 gpm.

10.5   Additional evaluations of recent leaks and usage of the 'new' Standard Action Levels

10.5.1 Comanche Peak Unit 1 (CP1) leak in December 2005

Comanche Peak Unit 1 experienced a leak starting in November 2005 which was finally fully identified and corrected on December 13, 2005. A detailed description of the leak investigation supplied by the Utility is as follows:

"Increased leakage in Unit 1 Containment has identified leakage in areas requiring further investigation and inspection to ensure location(s) of the leakage are identified and appropriate measures taken to control and rework at an available opportunity. Currently OPT-303 for Unit 1 indicates a RCS leakage rate of 0.09 gpm. An identified leakage of 0.0026 gpm from the Reactor Vessel Flange inner O-Ring was measured and quantified, Reference COA-2004-001770-0. First indication of RCS leakage has been measured (~25 ml per minute) at the Neutron Detector Well Fan drains. Chemistry results of the Neutron Detector Well fans drains indicate a presence of Tritium. As a result of these indications further investigation and inspection is necessary to ensure the source of the leakage is identified.

Investigations beginning 11/21/05 included review of operator rounds, completed activities, and activities in progress. The following observations were made:

- *Elevated containment sump run times began on 11/07/05 about 1 day after mode 3 entry from 1RF11 and prior to elevated RCS leakage indications. Containment sump 1 which does not normally run began pumping a volume equivalent to 0.01 gpm on 11/07/05.*

- *PRT level trend over time suggests ~2.5 gpd influent*

- *Systems connected to the RCS (RHR, CVCS, SI and sampling) were visually inspected. Very minor drips from packing leakoff lines and pump seals were noted*

- *Unit 1 and unit 2 RCDT totalizers were placed in service and the in service RHUT was instrumented to more accurately determine level changes. The results indicate no influents other than the RCDTs. This eliminates other sources such as LCV-0112A leakage and ECCS thermal relief valve leakage*

- *A containment entry was made on 11/22/05. Robotic inspection of all lower loop room areas was made as well as visual inspection of the containment areas outside the loop rooms. An RCS leak was identified on the RCP 1-01 #1 seal leakoff line just prior to 1CS-8362A, RCP 1 SEAL RETURN VENT VLV. RCP seal # 2 leakoff indications were recorded for all pumps*

- *A containment entry was made on 11/23/05 to verify by robotic inspection from above, the RCP 1-01 seal return leak Video shows the flange on the downstream end of flex hose CP1-CSFHCS-01 leaking in at least two places*

- *The reactor vessel o-ring leakage and RCP #2 seal leakoff flows were summed and compared to RCDT effluent. The two numbers are equal at 0.03 gpm. This was given to the Control Room staff as identified leakage for inclusion in OPT-303*

- *All floor drains in the Auxiliary, Unit 1 Safeguards and Fuel building except the NSSS Spent Resin Storage Tank room and VCT room were visually inspected. A total of 40 drops per minute was discovered from various packing leakoffs and pump seals. 1CS-0018, CCP 1-01 casing drain and Seal Water Injection Filter 1-02 were deemed unacceptable and work orders 4-05-165068-00 and 4-05-165069-00 were written to correct those leaks. The areas not inspected were due to high radiation dose rates in those areas*

- *The presence of SG chemicals in the containment sump discharge, elevated containment sump run times prior to elevated leakage from the RCS, and presence of water at the NDWCS fans suggest the presence of a secondary side leak. The leak is most likely in loop room 1 and/or 4 at the lower elevations*

- *On 12/2/05 photographs obtained during 1RF11 showed that the identification of the RCP 1-01 #1 seal leakoff flange leak to be incorrect. The leakoff flange is at an elevation above the grating and the leaking flange is clearly shown below the grating in the robotic inspection video. A task team was convened to assist in the leak investigation. Review of the three video tapes taken to date revealed as many as 10 possible mechanical connections that may be leaking. These locations are based on positive identification of pipe supports visible in all three videos. The line is identified as RCP 1-01 seal injection line between 1CS-8350A and the RCP*

- *A 100' articulating boroscope was obtained to allow visual inspection of each of the connections in the seal injection line without requiring loop room entry. Initially planned for 12/6/05. The inspection was delayed due to a scheduled graded emergency exercise and inclement weather. On 12/12/05 an inspection of the RCP 1-01 seal injection line was performed with the boroscope. A pipe cap leak, estimated at 10 dps was identified at 1CS-8364A, RCP 1-01 SEAL WTR INJ LINE DRN. Other areas, including the injection line flanges, 1CS-0108, RCP 1-01 SEAL WTR INJ LINE VNT, and all attached fittings were inspected. No other leakage was found*

- *On 12/13/05 a containment entry was performed to re-inspect areas previously covered due to apparent changing conditions. Robotic inspection of loop room 1 812' elevation revealed the absence of the dripping water from near the RCP 1-01 seal injection and seal return lines found on 11/22/05. Inspection by a site materials engineer showed that boron accumulation on the loop room floor and surrounding pipe supports was now almost completely dry. Also the condensation from NDWCS fan coil drains previously observed at about 25 ml/min was now absent*

> • *A pipe cap leak was found on 1PS-0008, PRZR 1-01 LIQ SPACE SMPL LN TC VLV. Steam was found issuing from the pipe cap, large boron accumulation was found on the valve and surrounding areas, and a steady stream of water was flowing across the floor to the floor drain. Note that this room was inspected on 11/22/05 with no sign of leakage. 1PS-0008 was tightened about 1/4 turn and the leakage stopped."*

Because Comanche Peak U1 was a Participant in the Standard Plant activity reported in Appendix G of Reference 2 and because they started supplying data to us effective December 1st, 2005, we have daily two hour snapshot values during the portion of the leak from Dec 1st to Dec 13th when the leak was fixed. Figure G-17 of Appendix G of Reference 2 shows a "clock running backward" portrayal of this leak. The clock was run backward to make it appear that the leak occurred at the end of the data collection process (after stable plant conditions existed) rather than at the start (when they did not). In addition, Figure G-15 shows a portrayal of the ULR data for Comanche Peak U1 (including the leak rate data) versus time using the baseline mean and baseline standard deviations determined for CP1. (The baseline values did not include the leak values from Dec 1st to Dec 13th.)

Reference 24 of Reference 2 herein includes the Excel spread sheet data used to construct Figures G-15 and G-17. Using the data from this Excel spreadsheet, we can see that the following Action Levels were set by this leak rate data. (Recall that the clock is running backward so Dec 13th precedes Dec 12th and so on in our description)

- The Action Level on Absolute ULR (7 day rolling average > .1 gpm) was exceeded for the first time on 12/05/05 and, then, also on Dec 4th through Dec1st.

- Exceedences above the baseline mean (i.e., .025) started accumulating on Dec 13th because the Dec 14th reading (.014 gpm) was below the baseline mean. Every value from Dec 13th to Dec 1st exceeded the baseline mean. Accordingly, 5 exceedences were first observed on Dec 9th, 7 on Dec 7th, and 9 on Dec 5th. This activates Action Level I in Section 5.2.2.

- The "$\mu + 2\sigma$" limit is approximately .081 gpm. Therefore Action Level II of Section 5.2.2 was activated on Dec 12th, 2005.

- The "$\mu + 3\sigma$" limit is approximately .109 gpm. Therefore Action Level III was actuated on Dec 9th, 2005 when a value of 0.130 was recorded. (This was the single largest value observed from Dec 1st to Dec 13th. Overall the values ranged from a low of .071 to the value of 0.130 gpm.)

Note that the Section 5.2.2 Action Levels were encountered as: Action Level II (Dec 12th), Action Level III (Dec 9th), Action Level I (Dec 5th). That is, Action Level II was first, Action Level III was second and Action Level I was last.

10.5.2 Millstone Point Unit 3 (MP3) Leak In April 2006

MP3 experienced a leak from Apr 7th, 2006 to Apr 15th, 2006. The information supplied by the Utility is as follows:

> *"See attached an Excel file that shows the recent RCS leak at MP3. The chart illustrates why inventory balance is not a major input to finding small increases in RCS leakage. There are two charts showing trends at a time that RCS leakage increased from 0.04 gpm to 0.06 gpm. One chart is in-leakage into the containment unidentified leakage sump. The sump in-leakage is shown by the white line. The other two lines on the chart are CTMT particulate and gaseous activity. It was a water leak, so we didn't expect atmospheric activity to increase. The other chart shows the inventory balance leak rates. On the RCS Inventory Leak Rate chart I've included the mean, Mean plus 2 STDEV, and Mean plus 3 STDEV.*

> *The leak started on 4/7/06 and was isolated on 4/15/06. The leak took in-leakage from approximately 0.04 gpm to 0.06 gpm. When it was isolated, leakage returned to approximately 0.045 gpm. During the leak, only four of the five days had inventory leak rate above the Mean and all leak rates were below Mean + 2 STDEV."*

(The Excel file referred to above is located in Attachment 11.1 and archived in Reference 24 of Reference 2 herein. The statements below regarding Action Levels are based on the data in that file.)

Examination of Attachment 11.1 data showed that the 7 day rolling average leak rate exceeded .1 gpm on both Apr 13th and Apr 14th. Therefore, if MP3 had been using the 7 day rolling average Action Level on absolute leak rate (which existed in draft form only at that date), this leak would have actuated an Action Level based only on RCS inventory balance values.

10.6   CONCLUSIONS

1. The review of the CP1 leak (Section 10.5.1) illustrates that small (< .1 gpm) constant leaks or slowly ramping leaks can easily be detected with the RCS Inventory method over relatively long periods of time (1 week -> 1 month or so).

2. Aggressive leak investigation such as that carried out by CP1 is worth more than all the Action Levels in the world. That is, put a good RCS inventory program in place, review the daily results, and act to resolve any problem on a timely basis.

3. Good two hour snapshot leak rate measurements can reveal small leaks (< .1 gpm) when data is recorded for a sufficient period of time (see Section 11.4 of Reference 2)

4. The 24 hour measurements described in Reference 2, Appendix G, Section G-5 can supplement the 2 hour measurements with little added effort. These readings will trap any periodic or episodic events which affect the RCS Inventory but that do not occur during the two hour snapshot measurements.

Table 10.1-1: RCS Leakage Event Data Base (sorted by "When Leak was Discovered")

Source	OE Report	Leak Rate Range	Units	How Leak was Detected	When Leak was Discovered	How Leak was Confirmed
Reactor Vessel Head Penetration	999-030116-1	Not published	Blank	Humidity, Activity and Inventory balance	Forced Outage	Visual Inspection
Reactor Vessel Head Penetration	328-021231-1	Boron Buildup	Pounds	Visual Inspection	Forced Outage	Visual Inspection
PZR Heater Nozzle	317-980417-1	Not published	Blank	Visual Inspection	Mode 3	Visual Inspection
PZR Heater Nozzle	529-001004-1	Not published	Blank	Visual Inspection	Mode 3	Visual Inspection
PZR Heater Nozzle	OE14436	Not published	Blank	Visual Inspection	Mode 3	Visual Inspection
PZR Level Instrument Line	318-980725-1	Boron buildup	Pounds	Visual Inspection	Mode 3	Visual Inspection
PZR Sample Line Thermal Relief	OE18468	14	gpm	Inventory Balance	Mode 3	Closed Isolation Valve
PZR Spray Valve Bypass Valve	OE13816	Not published	Blank	Visual Inspection	Mode 3	Visual Inspection
RCP Seal Injection Filter Housing	306-981222-1	Not published	Blank	Visual Inspection	Mode 3	Visual Inspection
RCS Hot Leg Instrument Nozzle	528-991002-1	Boron buildup	Pounds	Visual Inspection	Mode 3	Visual Inspection
RCS Instrument Tube Connection	OE19763	1.9	gpm	Instrument failure, sump level change	Mode 3	Visual Inspection
RCS Relief Line Bypass Isolation	280-980520-1	0.3	gpm	Visual Inspection	Mode 3	Visual Inspection
RCS Temperature Well Weld	280-011014-1	Not published	Blank	Visual Inspection	Mode 3	Visual Inspection
RCS Temperature Well Weld	285-001022-1	Not published	Blank	Visual Inspection	Mode 3	Visual Inspection
RCS Valve Body to Bonnet	346-030828-2	Not published	Blank	Visual Inspection	Mode 3	Visual Inspection
RCS Valve Packing	412-001215-1	Not published	Blank	Visual Inspection	Mode 3	Visual Inspection
Reactor Vessel Head Penetration	362-030210-1	Not published	Blank	Visual Inspection	Mode 3	Visual Inspection
SDC Suction Valve	336-990406-1	0.003 to 0.15	gpm	Inventory Balance	Mode 3	Visual Inspection
SDC System Relief	335-010402-1	80	gpm	Trending	Mode 4 shutting	Trending

Source	OE Report	Leak Rate Range	Units	How Leak was Detected	When Leak was Discovered	How Leak was Confirmed
Valve Lifting					down	
Charging Piping Weld	OE17677	0.07 to 0.09	gpm	Inventory Balance	Power Operations	Sump Level and Chemical Analyses
Charging Piping Weld	382-000306-1	1	gpm	Visual Inspection	Power Operations	Visual Inspection
Letdown Isolation Valve	250-030428-1	7	gpm	Mismatch between Charging and Letdown	Power Operations	Visual Inspection
Letdown Piping Weld	482-980801-1	0.05 to 0.09	gpm	Sump Inventory trend	Power Operations	Inventory Balance
Letdown Relief Valve	528-980520-1	325	Gallons	Area Radiation Monitor	Power Operations	Visual Inspection
Letdown Relief Valve	OE17515	Not published	Blank	VCT Level Drop	Power Operations	Local RMS
Pressurizer Manway	OE18785	0.07 to 0.275	gpm	Particulate Activity	Power Operations	Inventory Balance and Chemical Analyses
PSV Seat Leakage	369-010122-1	0.1 to 5.1	gpm	Trending	Power Operations	Inventory Balance
PSV Seat Leakage	369-010122-1	1.8 to 4.7	gpm	Trending	Power Operations	Inventory Balance
PZR Spray Valve Bypass Valve	390-020502-1	0.39 (up from 0.03 gpm)	gpm	Particulate Activity	Power Operations	Inventory Balance
PZR Spray valve bypass valve	285-010224-1	0.4	gpm	Temperature alarm on pressurizer spray valve (PCV-103-1) stem leak off line	Power Operations	Inventory Balance
PZR Steam Space Vent	281-980610-1	0.1	Gpm	Hydrogen Conc and Conmt Gaseous Activity	Power Operations	Inventory Balance and chemical samples
RCP Seal Injection line	280-980509-1	0.25	Gpm	Inventory Balance	Power Operations	Inventory Balance
RCP Seal Injection Filter Drain valve	311-000215-1	1.1	Gpm	Inventory Balance	Power Operations	Visual Inspection
RCP Seal Injection Filter housing	316-031218-1	10	Gpm	Visual Inspection	Power Operations	Closed Isolation valve
RCS Instrument Isolation Valve packing	443-000524-1	Not published	Blank	Visual Inspection	Power Operations	Visual Inspection
RCS Instrument Line Weld	LER 269-04001-1	1	Gpm	Inventory Balance	Power Operations	Particulate Activity

Source	OE Report	Leak Rate Range	Units	How Leak was Detected	When Leak was Discovered	How Leak was Confirmed
RCS Instrument Line Weld	OE12386,	1	Gpm	Not published	Power Operations	Inventory Balance
RCS Loop Bypass Valve	339-010119-1	10	Gpm	Trending	Power Operations	Inventory Balance
RCS Piping Weld	OE18110	1 to 2	Dps	Not published	Power Operations	Not published
RCS Piping Weld	OE20106	0.01	Gpm	Particulate Activity	Power Operations	Visual Inspection
RCS Valve Packing	412-001211-1	10	Gpm	Trending	Power Operations	Inventory Balance
Reactor Vessel Head Penetration	306-980123-1	0.08 to 0.3	Gpm	Particulate Activity	Power Operations	Inventory Balance
Reactor Vessel Head Penetration	425-030722-1	0.02	Gpm	Particulate Activity	Power Operations	Visual Inspection
Reactor Vessel Head Penetration	425-030830-1	0.1	Gpm	Particulate Activity	Power Operations	Visual Inspection
Reactor Vessel Head Penetration	327-020618-1	Not published	Blank	Water intrusion detection system	Power Operations	water intrusion detection system
RHR Discharge Check back leakage	395-990123-1	Not published	Blank	Trending of Plant Parameters	Power Operations	Trending
RSV Seat Leakage	OE15758	20	gph	Inventory Balance	Power Operations	Trending
RSV Seat Leakage	483-030325-1	Not published	Blank	Trending	Power Operations	Trending
SGTL	361-980918-1	300	gpd	SGTL calc.	Power Operations	Chemical analyses
SGTL	OE18266	20	gpd	SGTL calc.	Power Operations	Chemical analyses
PZR Heater Nozzle	336-031102-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
PZR Heater Nozzle	382-031024-2	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
PZR Heater Nozzle	LER 530-04001	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
RCP Seal Injection Line	395-031020-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
RCP Studs	289-990916-1	1,000	pounds	Visual Inspection	Refueling	Visual Inspection
RCP Studs	OE16095	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
RCS Drain Line	414-010919-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
RCS Flow Instrument	286-991017-1	1.6	gpm	Visual Inspection	Refueling	Inventory Balance
RCS Flow Instrument	311-980801-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
RCS Instrument Line	275-981217-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection

Source	OE Report	Leak Rate Range	Units	How Leak was Detected	When Leak was Discovered	How Leak was Confirmed
Weld						
RCS Instrument Line Weld	313-000215-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
RCS Piping Weld	OE17621	25 to 30	Dpm	Visual Inspection	Refueling	Visual Inspection
RCS Piping Weld	395-001007-1	100	pounds	Visual Inspection	Refueling	Visual Inspection
RCS Piping Weld	528-010331-2	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
RCS Piping Weld	OE19842	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
RCS Relief Line Bypass Isolation	423-980514-1	4	gpm	Visual Inspection	Refueling	Visual Inspection
RCS Temperature Well Weld	530-010930-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
RCS Valve Body to Bonnet	OE17118	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
Reactor Vessel Head Penetration	255-981227-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
Reactor Vessel Head Penetration	270-010428-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
Reactor Vessel Head Penetration	287-011112-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
Reactor Vessel Head Penetration	289-011012-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
Reactor Vessel Head Penetration	323-010501-2	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
Reactor Vessel Head Penetration	327-030324-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
Reactor Vessel Head Penetration	339-020914-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
Reactor Vessel Head Penetration	370-020317-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
Reactor Vessel Head Penetration	499-021002-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
Reactor Vessel Head Penetration	499-030125-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
Reactor Vessel BMI	OE17202 -	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection

Source	OE Report	Leak Rate Range	Units	How Leak was Detected	When Leak was Discovered	How Leak was Confirmed
RHR Heat Exchanger Studs	272-030108-1	Boron buildup	pounds	Visual Inspection	Refueling	Visual Inspection
SI Check Valve Seat	281-990507-1	Not published	Blank	Type C containment integrity testing	Refueling	Visual Inspection
RCS Drain down Event	286-991010-1	1,100	gallons	Trending	Shutdown	Trending
RHR Pump Discharge Relief	327-000314-1	10,000	gallons	Trending	Shutdown	Trending
RHR Pump Suction Relief	327-000926-1	500	gallons	Trending	Shutdown	Trending
RHR Pump Suction Relief	443-010108-1	300	gallons	Trending	Shutdown	Trending
RHR Suction Relief	311-981208-1	1,300	gallons	Trending	Shutdown	Trending
Reactor Vessel Head Penetration	OE17637	Davis Besse event impact. Not primary report	Blank	Multiple	blank	Blank

Table 10.1-2: Discovered at Power - Sorted by 'How Detected'

Source	OE Report	Leak Rate or volume	Units	How Detected	How Confirmed
Letdown relief valve	528-980520-1	325	gallons	Area Radiation Monitor	Visual Inspection, Miss-match between Charging and Letdown
Reactor Vessel Head penetration	999-030116-1	Boron buildup	pounds	Humidity, Activity and Inventory balance	Visual Inspection
PZR steam space vent	281-980610-1	0.1	gpm	Hydrogen and Gaseous Activity	Inventory Balance, chemical samples
PSV seat leakage	OE15758	20	gpm	Inventory Balance	
RCP Seal Injection line	280-980509-1	0.25	gpm	Inventory Balance	Inventory Balance
RCS Instrument line weld	LER 269-04001-1	1	gpm	Inventory Balance	Particulate Activity
RCP Seal Injection Filter Drain valve	311-000215-1	1.1	gpm	Inventory Balance	Visual Inspection
Charging piping weld	OE17677	0.07 to 0.09	gpm	Inventory Balance	Sump Level and Chemical analyses
Letdown Isolation valve	250-030428-1	7	gpm	Miss-match between Charging and Letdown	Visual Inspection
RCS piping weld	OE18110	1 to 2	Dps	Not published	
RCS Instrument line weld	OE12386,	1	gpm	Not published	Inventory Balance
RCS piping weld	OE20106	0.01	gpm	Particulate Activity	Visual Inspection
Reactor Vessel Head penetration	425-030722-1	0.02	gpm	Particulate Activity	Visual Inspection
Reactor Vessel Head penetration	425-030830-1	0.1	gpm	Particulate Activity	Visual Inspection
Pressurizer man-way	OE18785	0.07 to 0.275	gpm	Particulate Activity	Inventory balance and chemical Analyses
Reactor Vessel Head penetration	306-980123-1	0.08 to 0.3	gpm	Particulate Activity	Inventory Balance
PZR Spray valve bypass valve	390-020502-1	0.39 (up from 0.03 gpm)	gpm	Particulate Activity	Inventory Balance
SGTL	OE18266	20	Gpd	SGTL calc.	Chemical analyses
SGTL	361-980918-1	300	Gpd	SGTL calc.	Chemical analyses
Letdown piping weld	482-980801-1	0.05 to 0.09	gpm	Sump Inventory trend	Inventory Balance
PZR Spray valve bypass valve	285-010224-1	0.4	gpm	Temperature alarm on pressurizer spray valve (PCV-103-1) stem leak-off line	Inventory Balance
RCS loop bypass valve	339-010119-1	10	gpm	Trending	Inventory Balance

Source	OE Report	Leak Rate or volume	Units	How Detected	How Confirmed
RCS valve packing	412-001211-1	10	gpm	Trending	Inventory Balance
PSV seat leakage	369-010122-1	0.1 to 5.1	gpm	Trending	Inventory Balance
PSV seat leakage	369-010122-1	1.8 to 4.7	gpm	Trending	Inventory Balance
PSV seat leakage	483-030325-1	Not published		Trending	Trending
RHR Discharge Check back leakage	395-990123-1	Not published		Trending of Plant Parameters	Trending
Letdown relief valve	OE17515	Not published		VCT Level drop	Local RMS
Charging piping weld	382-000306-1	1	Dpm	Visual Inspection	Visual Inspection
RCP Seal Injection Filter housing	316-031218-1	10	gpm	Visual Inspection	Closed Isolation valve
RCS Instrument isolation valve packing	443-000524-1	Not published		Visual Inspection	Visual Inspection
Incore Thimble	327-020618-1	Not published		Water intrusion detection system	water intrusion detection system

Table 10.1-3: Power Operations - Sorted by Source

Source	OE Report	Leak Rate Range	Units	How Detected	How Confirmed
Charging piping weld	OE17677	0.07 to 0.09	gpm	Inventory Balance	Sump Level and Chemical analyses
Charging piping weld	382-000306-1	1	gpm	Visual Inspection	Visual Inspection
Incore Thimble	327-020618-1	Not published		Water intrusion detection system	water intrusion detection system
Letdown Isolation valve	250-030428-1	7	v	Miss-match between Charging and Letdown	Visual Inspection
Letdown piping weld	482-980801-1	0.05 to 0.09	Gpm	Sump Inventory trend	Inventory Balance
Letdown relief valve	OE17515	Not published		VCT Level drop	Local RMS
Letdown relief valve	528-980520-1	325	gallons	Area Radiation Monitor	Visual Inspection
Pressurizer man-way	OE18785	0.07 to 0.275	gpm	Particulate Activity	Inventory balance, chemical Analyses
PSV seat leakage	OE15758	20	Gph	Inventory Balance	
PSV seat leakage	369-010122-1	0.1 to 5.1	gpm	Trending	Inventory Balance
PSV seat leakage	369-010122-1	1.8 to 4.7	gpm	Trending	Inventory Balance
PSV seat leakage	483-030325-1	Not published		Trending	Trending
PZR Spray valve bypass valve	390-020502-1	0.39 (up from 0.03 gpm)	gpm	Particulate Activity	Inventory Balance
PZR Spray valve bypass valve	285-010224-1	0.4	gpm	Temperature alarm on pressurizer spray valve (PCV-103-1) stem leak-off line	Inventory Balance
PZR steam space vent	281-980610-1	0.1	gpm	Hydrogen and Gaseous Activity	Inventory Balance, chemical samples
RCP Seal Injection Filter Drain valve	311-000215-1	1.1	gpm	Inventory Balance	Visual Inspection
RCP Seal Injection Filter housing	316-031218-1	10	gpm	Visual Inspection	Closed Isolation valve
RCP Seal Injection line	280-980509-1	0.25	gpm	Inventory Balance	Inventory Balance
RCS Instrument isolation valve packing	443-000524-1	Not published		Visual Inspection	Visual Inspection
RCS Instrument line weld	LER 269-04001-1	1	gpm	Inventory Balance	Particulate Activity
RCS Instrument line weld	OE12386,	1	gpm	Not published	Inventory Balance
RCS loop bypass valve	339-010119-1	10	gpm	Trending	Inventory Balance
RCS piping weld	OE18110	1 to 2	Dps	Not published	
RCS piping weld	OE20106	0.01	gpm	Particulate Activity	Visual Inspection
RCS valve packing	412-001211-1	10	gpm	Trending	Inventory Balance
Reactor Vessel Head penetration	999-030116-1	Boron buildup	pounds	Humidity, Activity and Inventory balance	Visual Inspection
Reactor Vessel Head penetration	425-030722-1	0.02	gpm	Particulate Activity	Visual Inspection
Reactor Vessel Head penetration	425-030830-1	0.1	gpm	Particulate Activity	Visual Inspection
Reactor Vessel Head	306-980123-1	0.08 to 0.3	gpm	Particulate Activity	Inventory Balance

Source	OE Report	Leak Rate Range	Units	How Detected	How Confirmed
penetration					
RHR Discharge Check back leakage	395-990123-1	Not published		Trending of Plant Parameters	Trending
SGTL	OE18266	20	Gpd	SGTL calc.	Chemical analyses
SGTL	361-980918-1	300	Gpd	SGTL calc.	Chemical analyses

11   ATTACHMENTS

11.1   Summary of utility comments received during development

11.2   Excel Spreadsheet for April 2006 Leakage at Millstone Unit 3

Attachment 11.1

Summary of Utility Comments Received during Development

Item	Name/Utility	Section	Comment	Westinghouse Response
1.	Don Vogt Palo Verde (2/27/06)	4.0	Definition: LEAKAGE Type: Non-RCPB (Non-Reactor Coolant Pressure Boundary Leakage). Later in the procedure "interconnected system leakage" is the term used. Should be consistent.	Agree. "Intersystem leakage" changed to "Non-Reactor Coolant Pressure Boundary Leakage" in Section 6.1 Item 4. Change incorporated in r11.
2.	Jim Lambert Farley (3/17/06)	4.0	Definition of LEAKAGE Type: Gross - "(see def.)" infers that there is a definition for RCS control volume included. I see no such term in the definitions section.	Added definition of RCS Control Volume as well as Reactor Coolant Water Volume. Change incorporated in r11.
3.	Jim Lambert Farley (3/17/06)	4.0	In the definitions section, it is unclear what type of leakage "RCP seal water injection or leakoff" is considered. It is specifically excluded from identified and unidentified leakage. Should there be another definition for "controlled" leakage?	RCP seal leakage is included in IDENTIFIED LEAKAGE as a change in RDT inventory. No change.
4.	Jim Lambert Farley (3/17/06)	5.1.1	Page 13, RCS is misspelled in first sentence under step 5.1.1.	Corrected. Change incorporated in r11.
5.	Scott Eidem FCS (3/17/06)	5.1.1	First Paragraph - "RCS" has transposed letters.	Corrected Change incorporated in r11.
6.	Scott Eidem FCS (3/17/06)	5.1.1	Subpoint 4 – What is meant by "statistical independence" – a definition is needed in section 4 or here for clarification.	Item 6 of Section 11.12 and Figures D-30 and D-31 of Appendix D of Ref. 2 describe what is meant by "statistical independence". Roughly speaking, the issue was raised in Ref. 2 because all of the simulations and related work in Ref. 2 were based on "statistical independence" in that each simulated daily observation was based on an independent sample of a normally distributed random number. So, knowing "today's value" gives no hint regarding "tomorrow's value". We realized that some members were using an "ending value" for one interval as the "starting value" for the next interval and, as a consequence, successive observations were not independent. That is, an

Item	Name/Utility	Section	Comment	Westinghouse Response
				"ending" RCS inventory value which is too high due to random errors reduces the leak rate estimate for the current sample and is expected to result in an increased leak rate estimate for the next time interval when the high "ending" inventory is used as a "starting" inventory. Westinghouse will add a definition of this term along with other similar terms to Ref. 2.
7.	Scott Eidem FCS (3/17/06)	5.1.2	First Paragraph - What is the definition of "statistically valid" and "statistically significant"? A definition of each of these terms should be provided in section 4.	Deleted the phrase, "determine the statistical significance of the change and to" Change incorporated in r11. The term "statistically valid" refers to Item (1.) in paragraph 5.1.1. That is, the current quarter's data and the previous quarter's data should be screened with the (Excel) F-test to demonstrate that the standard deviations for the two quarters are not significantly different and then the t-test to demonstrate that the means for the two quarters are not significantly different. Note that NRC App. D does not require any such evaluation when the baseline values are updated. (That is, the current (30 day) value is used to replace the oldest (30 day) value at the end of each 30 day period with no comparison. A critique of the current NRC App. D will be added to Ref. 2 in the forthcoming revision.) Westinghouse will revise the document to indicate what "statistically valid" means. The term "statistically significant" (used in paragraph 1 of 5.1.1) means some observation or set of observations is "abnormal" enough that you should be aware of it & do something.

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8.	Scott Eidem FCS (3/17/06)	5.1.2	Subpoint 2, pg 15 – What is the statistical significance of these (i.e. 7, 14, 21 and 30 day) time periods?	These values came from (integrated) customer comments in response to the last RCS Leak Rate Survey. In fact, I believe FCS "got the ball rolling" with your use of the initial 7 day value during the startup and the number kept doubling after that. NRC App. D states that a new operating cycle should develop baseline values "upon the first three months of steady state leakage data following an outage" and then adds that the current baseline values "should be lower than … the period just prior to shutdown". I'm not sure if they mean that no baseline is available for the first 90 days of operation or if they really intended to use the baseline values prior to shutdown for the first 90 days. In any event, basing the standard deviation on such a short period of time (i.e., 7 days) can be a little dicey because two standard deviations from two samples of size 7 from the same population can easily vary by a factor of 2 or more. My personal opinion is that a "control chart" approach based on the 90 days of operation before shutdown should be used. That is, create a plot versus time, put the pre-shutdown mean on it as a straight line, with parallel lines at the mean +/- standard deviation & mean +/- 2 standard deviations and simply plot the daily average values. If they fall above & below the old mean, the mean probably didn't move much due to the refueling. If they fall mostly below, refueling maintenance "fixed" stuff, if they fall mostly above, the reverse is true. If the values challenge the 1 or 2 standard deviation limits (when any mean shift is taken into account), the standard deviation may have increased. After [30] days of operation, the data can be used to determine reasonable baseline values.

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				Finally, I think the median is probably better than the mean for small samples after startup since, unlike the mean, the median is essentially immune to any outliers.
9.	Don Vogt Palo Verde (2/27/06)	5.1.2	Part 1. Charging pumps are switched weekly, suggest wording to the effect that if a change in leakage is seen immediately following a change in operating charging pumps, then charging system leakage should be investigated) Palo Verde measures charging pump leakage and subtracts it from the total RCS (gross) leakage calculated.	Change incorporated in r11.Added the following additional explanation: .... Non-RCPB LEAKAGE, e.g. charging pump leakage, impacts the reactor coolant system gross LEAKAGE, but it occurs outside the RCPB. Therefore, it is not included in IDENTIFIED LEAKAGE or UNIDENTIFIED LEAKAGE. A change in gross leakage immediately following a change in operating charging pumps should be investigated and the Non-RCPB LEAKAGE term in the unidentified leak rate calculation adjusted accordingly.
10.	Jim Lambert Farley (3/17/06)	5.2.1	Page 17, second from last paragraph, "[5000] gpm" should be "[5000] gallon".	Agree. Corrected.
11.	Scott Eidem FCS (3/17/06)	5.2.1	Page 17 – What is the proposed tool to identify a slow, creeping small leak if not the Absolute Unidentified Leak Rate Limit? It seems that the action trigger levels in place will still flag a "large" leak, even if the baseline cycle average elevates over time.	The tool is the "two-sample" t-test. As discussed on p. 17, the limit for passing the two-sample t-test applied to two successive 90 day data sets is about ¼ (.25) of your baseline standard deviation. That is, you will fail the test if the creep is much bigger than this. In addition, simply keeping track of the successive baseline values will show even a small continuous excursion in the baseline mean. "There is no problem seeing what is happening if you look at what is happening. Not looking is the problem." It is OK for the baseline mean to creep as time goes along although one member told us he didn't ever see

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			Also, isn't an increasing average leak rate expected over the cycle as various components degrade? How is this accounted for in the calculations?	such a thing. It is accounted for in the Section 5.2.2 Action Levels by the periodic adjustments in the quarterly baseline mean. If the measurements increase enough in one calendar quarter, the Section 5.2.2 Action Levels may be encountered near the end of the quarter. NRC App. D refreshes the baseline every 30 days vice 90 days in our Recommendations. I like the 90 day periods because small increases in the mean can be discerned when two sets of 90 values are compared relative to one set of 90 and one set of 30. However, if you get into Action Levels due to a small creep, it is probably better to use the NRC App. D approach. Note that the numerical values in Sections 5.2.1 and 5.2.3 are "hard" limits. Time in cycle doesn't alter the limits but may impact on the Actions taken when limits are encountered. Additional thoughts for discussion: The Action Levels are not intended to make you aware of a problem. They are intended to tell you when a problem you have been tracking is reaching a point where action is required."
12.	Mark Handrick Dominion (3/20/2006)	5.2.1	In several places, the draft states that negative daily values for unidentified leakage should be entered as 0.0 gpm for trending purposes. I believe that this guidance is incorrect, since it will introduce an artificial high bias into the rolling averages. Negative leak rates should be considered for the trending purposes discussed in the draft.	See the discussion for Item # 16. The rolling averages described in Section 5.2.1 and Section 5.2.3 are only intended to detect proximity to the "hard limits" in those Sections. The "rolling averages" discussed in Section 5.1.1 and in Section 11 of Ref. 2 are intended to include all values (negative and positive) used to determine the baseline values. I can understand that Members might be confused about the use of negative values in some calculations

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				and not in others. As stated in Item #16, I don't think it makes much difference in the Sections 5.2.1 and 5.2.3 results in any "real world" situation. So, we can revise if it simplifies things for you.
13.	Mark Handrick Dominion (3/20/2006)	5.2.1	Section 5.2.1 reports absolute unidentified leak rate limits in brackets. What is meant by the brackets? Are plants free to set these limits individually? Please clarify.	The brackets were intended to indicate that the numbers were "proposed" values for the Members to critique and "vote on". (We think the numbers are high enough so no one currently has a problem with them & low enough to push you into an Action Level before things get out of hand.) It would be helpful to get some feedback in the next Telecom on the acceptability of these values or suggestions for alternatives. What would be too small? The following rules were discussed with group. No objections were raised. They have been applied to r11. Square brackets indicate values that are to be plant specific. The guidelines will describe the intent and what the number is supposed to represent. The utility will develop a plant specific number for use at their plant. Curly-brace brackets identify numbers that are under development for the standard guidelines. Once they are finalized by the groups they will be removed. The guideline numbers then apply to everyone.
14.	Jim Lambert Farley (3/17/06)	5.2.2	Page 18, under step 5.2.2, action level 3, recommend removing "consecutive" as it is meaningless, and this would be consistent with the action levels under step 5.2.1. Also recommend using the numbers in brackets for all three actions levels under step 5.2.1 (page 16) as	Agree. Removed "consecutive". Change incorporated in r11. Westinghouse is not sure what is meant by second comment. One explanation is the referenced section

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			was done in 5.2.2.	numbers are reversed. If this is the case, there are no generic mean (μ) and the standard deviation (σ) values. They are plant specific. Therefore, no change.

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15.	Jim Lambert Farley (3/17/06)	5.3	Page 20, insert "the" between "perform" and "following" in the line before the 4 actions at the bottom of the page.	Corrected. Change incorporated in r11.
16.	Bob Couture Seabrook (3/13/06)	5.3.2	In the section 5.3.2 discussion on the 30 day total integrated leak limit in gallons (top of page 19), it is stated that "any day that has a negative leak rate should be entered as zero". I believe that the companion WOG standardized leak rate measurement effort does state that negative leak rates can occur and that they are statistically valid. Why can't the calculation of a rolling 30 day total integrated leak rate not use the negative values?	Westinghouse has reemphasized checking for outliers in the final report. The intent is as follows: Part 1: Unlike NRC App. D, we continue to recommend that the calculation of the Baseline mean and standard deviation include both positive and negative "daily average" data values. Retaining these values rather than ignoring them "forces" the distribution to approach normality which then coincides with the models and conclusions documented in the Section 11, Ref. 2 simulations. (Note that all the Standard Plant measurements passed the normality tests to date.) In addition, the F-test, the two-sample t-test, and the substitution of the mean in place of the median start to fall apart when the distribution of observations is not normal. (We recognize that the mean of the data will increase if negative values are deleted (which increases the Action Level "triggers" in Section 5.2.2). At the same time, the standard deviation will decrease if negative values are discarded.) Finally, I think we all agree that the negative values are not "real" in the sense that water is not appearing from nowhere. That is, negative values are appearing due to the accumulation of errors of measurement and so on (i.e., the so called "slack variable" effect discussed in Sec. 11.1 of Ref. 2). As a consequence,

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				the negative values provide "real information" about the accuracy of the system. In particular, we would expect that spurious positive readings of the same magnitude as the spurious negative readings must be occurring (provided that there are no significant spurious biases). Part 2: Substituting "0.0" for negative values in Sections 5.2.1 and 5.2.3 is not intended to be applied in deriving the baseline values described in 5.2.2. These adjustments are intended to add conservatism to the calculation of the "hard limits" on the absolute unidentified leak rate limits of Section 5.2.1 and the total integrated leakage limits of Section 5.2.3 only. Note that substituting a "0.0" for a negative value is not the same as deleting the value. That is, if the daily values were "ringing" back & forth from +.1 gpm to -.1 gpm, the average would tend to 0.0 gpm, ignoring the negative values would produce an average of +.1 gpm and the stated approach would tend to .05 gpm (n/2 "+.1" values and n/2 "0.0" values). Although I haven't done any calculations in this area, I think keeping or rejecting negative values for these hard limits" probably won't change the result in a significant way provided that the baseline mean is not too negative. That is, if you are seeing a lot of +.1 gpm values, it is either because the mean is too high (in which case large negative values are unlikely) or because your standard deviation is too high (in which case you will get into an Action Level & have to look into the reasons.) Note that if one plant runs at a baseline value of -.05 gpm and another runs at +.05 gpm, the +.1 gpm absolute limit doesn't seem to have a

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				consistent meaning. That is, the first plant needs a step increase of +.15 gpm to get to the +.1 limit whereas the second only needs a +.05 gpm increase. While the +.05 gpm may be "real" for the second plant, the -.05 gpm cannot be "real" for the first plant and, per Ref. 2, credit should not be taken for the negative baseline value. (Some Standard Plant observations show small negative baseline values.)"
17.	Scott Eidem FCS (3/17/06)	5.4.1	Recommend adding an action for each of the Tier response guidelines – "inform NRC inspector of actions taken" or something to that effect, especially since the NRC Inspection Plan 2515 Appendix D action criteria are also part of the Tier Action level triggers.	No change. The consensus of the group was to not include NRC notification in the guidelines as a required action upon reaching a limit. Note that the current NRC App. D has Action Levels that agree with Section 5.2.2. However, the actual values will be different since the baseline means are calculated in a different way. (App. D ignores negative observations.) Westinghouse will include a critique of the latest Appendix D guidance in Reference 2.
18.	Scott Eidem FCS (3/17/06)	5.4.3	Action 2.b – Isn't a small concentration of boric acid expected? Shouldn't this be reworded to account for "larger than expected/historic boric acid concentrations"?	Accepted. Added, "larger than expected". Change incorporated in r11.

19.	Scott Eidem FCS (3/17/06)	5.4.3	Action 7 – What is the "RCS leak investigation procedure"? Is this document WOG prepared or taken from existing plant procedures?	Added "plant specific". Change incorporated in r11. Westinghouse review of utility documents indicated that many utilities already have written RCS leak investigation guidance. Our reference to it in this report is intended to be brief and generic, not to include a detailed description of an "RCS leak investigation Program." I believe INPO already has such guidance.

| 20. | Bob Couture Seabrook (3/13/06) | 6.2 | Even without the issue of making the document "mandatory", I believe that the current scope of the document provides a large amount of information that can easily be misunderstood to imply a plant commitment or requirement. These additional sections of the document should be removed or severely trimmed back. A few examples of this type of information are listed below:

• Section 6.2 on containment sump monitoring. For the very small leak rates that we are discussing (on the order of 0.05 gpm), I believe that industry experience shows that these containment sump inventory monitoring systems are not the first line of defense. While they serve as required backup method, they do not have the desired accuracy or reliability for the very small leak rates. However, by inclusion in this document, the context implies the systems are more accurate/useful for small leaks than they really are.
➢ | Westinghouse with clearly differentiate between what is generic guidance and background information (not a requirement) and what is a "mandatory" requirement. |
| 21. | Bob Couture Seabrook (3/13/06) | 6.3 | • Section 6.3 runs into many plant licensing issues that can easily cause problems. Some specifics for Section 6.3 are noted below:
➢ The first paragraph at the top of page 27 lists a specific value for gaseous activity monitor instrument sensitivity.
➢ Section 6.3.1, item 2 discussion on sampling system design and how it "shall be designed" in accordance with the listed ANSI standard.
➢ The Section 6.3.1 item a listing of assumptions for design calculations invokes a specific source term specification (ANSI N237)
➢ The Section 6.3.1 item 4 listing of assumptions for design calculations | See response for #20. This is just a discussion on gaseous and particulate monitoring.

One thing we might want to do is change "shall be" references to "should be" or "may be", but again, these are already requirements and don't represent anything new. |

			contains specific plateout factors to be used.	
22.	Jim Lambert Farley (3/17/06)	General	WOG Westinghouse Owners Group - Should be changed throughout the document to PWROG Pressurized Water Reactors Owners Group.	Agree. WOG changed to PWROG.
23.	Bob Couture Seabrook (3/13/06)	General	The issue of the WOG executive committee making this document (or portions of it "mandatory") needs to be addressed/resolved. Many sections of this draft report contain additional information that on one hand is useful but can easily become "problematic" if made mandatory. My input on this is that the following should be the only items available to be made mandatory: • Establishment of a "tiered" action level response for increasing RCS unidentified leak rates. • The basic leak rates or "events" (i.e. X gallons per month) that correspond to each level. • Types of plant activities and evaluations associated with exceeding a specified action level.	See response for #20
24.	Mike Hess Millstone Point (3/29/2006)	4.0	HISTORICAL BASELINE - consider adding the disclaimer that the first seven days after an outage (or until leak rate steadies out) should not be included in any averages.	Section 5.1.2 states that: "It is the responsibility of each plant to maintain a valid baseline and establish rules for changing it." Without extensive review, it is not possible to come up with a method to define the baseline at startup which will work for all Members.

25.	Mike Hess Millstone Point (3/29/2006)	5.1	First paragraph. Consider changing "The mean is obtained by averaging the 90 daily leak rate values." to "The mean is obtained by averaging the valid leak rate values within a calendar quarter."	Accepted. Change incorporated in r11.
26.	Mike Hess Millstone Point (3/29/2006)	5.1.2 (1??)	Consider deleting the Reference 2 recommendations.	Reference 2 is currently under revision. As a consequence, the Ref. 2 Recommendations may be revised. In particular, items 4 – 6 in the list in Section 5.1.1 may be deleted. In any event, these Recommendations are not mandatory and Members can ignore them if they so choose.
27.	Mike Hess Millstone Point (3/29/2006)	5.1.2	First paragraph, delete the last sentence. It doesn't matter if it is statistically valid. The data is what it is.	Pls. see discussion of "statistically valid" in Item 7. We agree that you will probably use the data in any event. However, we think there is "value added" by running an Excel F Test & two sample t-test to see if there has been a statistically significant increase in the baseline mean in the last quarter. This evaluation forms a barrier against an unidentified "creeping mean"
28.	Mike Hess Millstone Point (3/29/2006)	5.2.1	Delete the requirement to set negative values to 0.0 and to use the previous day value when data is not available. If we are hanging our hat on a statistical analysis, don't skew the statistics.	Pls. see discussion for Item # 16. The censoring of negative values is not intended for use in calculating the baseline mean only in monitoring for the absolute and integrated leak rate limits in Sections 5.2.1 and 5.2.3. It seems to us that any time a "real" (numerical) limit is imposed, we need to "level the playing field" by making sure that a plant operating with a long term significant negative baseline value does not get an undue credit with respect to any absolute limits. Note that the limits in Section 5.2.2 are measured with respect to the mean so, in principle, it doesn't matter whether the mean is positive or negative for those limits. (We are also considering addressing this issue by placing a limit on the baseline mean of something like -.025 or greater.)

29.	Mike Hess Millstone Point (3/29/2006)	5.2.1	Where 5000 is used it should be gallon, not gpm.	Change incorporated in r11.
30.	Mike Hess Millstone Point (3/29/2006)	5.2.3	Use the weekly, monthly, or quarterly averages to determine Total Integrated Unidentified Leakage. It's less math and it eliminates the concern with missing data points. It also reduces the chance for a negative number, but, if it is negative, use it. Protect the statistical validity of the calculation.	Anything that simplifies the calculation without compromising the intent is fine. Not sure about including negative values. For most plants that may not affect the result, but for some it will.
31.	Mike Hess Millstone Point (3/29/2006)	5.2.3	Also, don't measure in MODE 2 and 3. We usually aren't in these modes past the seven days that the WCAP says it takes to swell packing. In fact, the 5000 number should only apply to steady state power operation or valid numbers.	The short term limit does apply during steady state conditions as described in the 1st paragraph of Section 5.2.3. The long term limit applies to the entire operating cycle, from startup following refueling to shutdown prior to refueling. In both cases, the limit is calculated using the average daily leak rate results (if available). It is useful to start running leak rates in Mode 3 in parallel with performing the containment walkdown, leak inspection and repairs to correct leaks. Even though the accuracy of the result may be suspect, it affords the opportunity to validate the response of the calculation to changes in leakage. Also, a secondary purpose of the accumulative limit is to monitor and limit the long term deposition of boric acid on stainless steel surfaces. Boric acid can be deposited from leaks any time the RCS is pressurized.
32.	Mike Hess Millstone Point (3/29/2006)	6.3	Last paragraph, delete the last sentence. Please don't suggest that anyone is going to correlate activity to leakage rates.	Agree. Sentence deleted.
33.	Hank Stroup Sharon Harris (4/11/2006)	General	Though it is certainly possible some elements of the program could be misunderstood and incorrectly implemented, the statistical evaluations described appear sound and reasonable. For some plants (and	The evaluations are really pretty straightforward and easy if Excel is used. As with everything, there is a learning curve.

			Harris Nuclear Plant would be in this group), the statistical evaluations will require dedication of more resources than that currently assigned.	
34.	Hank Stroup Sharon Harris (4/11/2006)	General	The one issue that I have not seen address is feedback following implementation of this program. I am 99.999% sure that after a year or so following implementation, at least one plant will raise identify at least one issue that no one thought of during program development. There needs to be some mechanism for the PWROG to formally collect and share the feedback that will most certainly occur. Are there any plans to solicit and evaluate feedback?	Comment to be referred to PWR Owners Group and OSC for response, i.e. generating a PA to collect/respond to feedback and a possible follow-up workshop.
35.	Bruce Bauer Palisades (4/11/2006)	5.1.1	You should describe the F-test and two sample t-test some where in this document on how it is to be performed.	Addressed by response to comments 6, 7 and 8.
36.	Bruce Bauer Palisades (4/11/2006)	5.1.1	What does statistical independence" mean?	Addressed by response to comments 6, 7 and 8.
37.	Bruce Bauer Palisades (4/11/2006)	5.1.2	What does this mean by statistically valid?	Addressed by response to comments 6, 7 and 8.
38.	Bruce Bauer Palisades (4/11/2006)	5.1.2	Why not a 60 day and then 90 day baseline? Is the intent that the second month you do a 7 day then 14 day, etc.?	Addressed by response to comment 8.
39.	Bruce Bauer Palisades (4/11/2006)	5.2.1	What is the 2 sample t-test? This seems way to complicated	Addressed by response to comments 6, 7 and 8.
40.	Bruce Bauer	5.2.1	What are you saying here? Do you mean [5000]	Addressed by response to comment 10.

	Palisades (4/11/2006)		gallon limit.	
41.	Bruce Bauer Palisades (4/11/2006)	5.2.1	Everything assumes daily values. We do leak rate ever odd day of month and by TS only required every 3rd day.	The Section 5.2.2 Action Levels (which are similar to the current NRC Appendix D Action Levels) can use your "odd day" measurements without any modification. As a result, you would typically have about 45 observations per calendar quarter. Note that simply using the method of Sections 5.2.1 and 5.2.3 (i.e., "Any missing day's value should be set to the value recorded for the previous day.") will have no effect on the quarterly mean and standard deviation provided that a value of 90 is used for the number of data points. However, this could be confusing and, strictly speaking, misstates the number of degrees of freedom used to calculate the standard deviation. As a result, we recommend that the Section 5.2.2 Action Levels be based on exactly the data recorded at the site. Westinghouse will modify Section 5.2.2 to add this statement. However, Sections 5.2.1 and 5.2.3 should use the stated method (i.e., "Any missing day's value should be set to the value recorded for the previous day."). Of course, you will always have missing day's values. Without this treatment of the missing day's values, you would, in principle, take twice as long (i.e., 14 days) to get 7 values in excess of +0.1 as another plant with the same problem that was recording daily values. The treatment of "missing day's values" was added to put everyone on an equal footing. Note the statement regarding the need to measure on at least a daily basis if a single observation of +0.15 gpm is observed. (In the discussion section of 5.2.1).
42.	Bruce Bauer	5.2.3	What is the benefit of total integrated leakage limit?	As discussed in Section 5.2.3, the purpose of this limit is to place a definite upper bound on the total amount

	Palisades (4/11/2006)			of unidentified leakage that can accumulate in one 30 day period (5,000 gallons) and in one Operating Cycle (50,000 gallons). Without these limits it is potentially possible to leak something like 80,000 gallons during one cycle without "hitting" any other Action Levels (i.e., if the Baseline Mean is limited to +0.075 and the plant operates right at this limit with essentially a "0.0" standard deviation for 24 months, the total leakage will be about 80,000 gallons). Note that under this scenario, the plant will never violate the 5.2.1 or 5.2.2 limits. We believe that these limits are high enough to not cause any undue hardship and we feel that there is a definite value in "knowing" that there is an upper bound on the amount of water (and boric acid) that can be "lost" as unidentified leakage. **Please let us know if you disagree with our assessment.**
43.	Bruce Bauer Palisades (4/11/2006)	5.4.3	After 2.b, add the requirement to check for activity.	Accepted. Change incorporated in r11.
44.	Bruce Bauer Palisades (4/11/2006)	5.4.3	4. This first requires that you determine the source of the leak.	Accepted. Added step to identify sources of the leak prior to quantifying the leakage. Change incorporated in r11.
45.	Bruce Bauer Palisades (4/11/2006)	6.1	3.b. Does the "and" require us to have a leak detection systems on the identified leak rates. I thought the requirement is that we are capable of detecting a leak rate change of 1 gpm leak within 1 hour.	Leak detection equipment must be capable of monitoring 1gpm leak within one hour Removed second half of part 3.6 containing design requirements for "monitored with sensitivity capable of detecting a 1 gpm leak within 1 hour (RG 1.45 requirement for leak detection systems)..
46.	Bruce Bauer	6.2	Last paragraph. Why is this paragraph here.	In order to maintain background radiation levels as low

	Palisades (4/11/2006)			as possible to maximize the sensitivity of gaseous radioactivity monitors.

Final Review Comments

47.	Mike Hess Millstone Point (8/24/2006)	Section 4	Joe, nice job. Just a few comments. Section 4, Leakage Investigation Plan. Consider eliminating the word abnormal. Abnormal is associated with Procedures that address higher leakage than we are addressing.	Comment Accepted. Deleted "abnormal".
48.	Mike Hess Millstone Point (8/24/2006)	Section 5.2.2	Section 5.2.2, first paragraph after the numbered items: Consider changing from: That is, a run of 9 values above the mean in one quarter should be statistically significant. to: That is, a run of 9 **consecutive** values above the mean should be statistically significant.	We will add the word "consecutive". Typically the term "run" implies "in a row" or consecutive but this is a good clarification. We will eliminate the word "quarter" but please recognize: The length of a "statistically significant" run depends on the number of samples inspected or, here, the length of time involved (see Eqn. 11.1). That is, a run of length 9 is not unexpected once or so in a two year period when no changes in the leak rate have occurred. (See the discussion in Section G-4.) If you have a run of length 8 as of September 30th (i.e., the end of the third quarter) and you use the third quarter data (including the run) to define the baseline values for the fourth quarter, it is possible that no exceedence will be recorded on October 1st. Common sense needs to be used in a situation like this.

49.	Mike Hess Millstone Point (8/24/2006)	Section 5.4	Should the third Action Levels in Tier two and three be switched. 5000 gallons in 30 days is 90,000 gallons in an 18 month operating cycle. This would represent a significantly greater leak than 50,000 gallons in an 18 month operating cycle. All of the other Action Levels represent increased leakage as they progress up the Tiers.	We think the Action Levels are OK as is. That is, 50,000 gallons is 10 times more water (and potentially boric acid) than 5000 gallons. So, as stated in Section 5.2.3, you can leak about 5,000 gallons in one month but you can't leak 5,000 gallons in every month. The idea of the short term limit and the associated Action Level is that you will hit the Action Level and address the problem so that the next month is less severe. We recognize that you could leak 4,900 gallons per month for 10 months before hitting the 50,000 limit. Again, common sense should prevail. If you see several months of high leakage you should address the problem rather than wait for the allowed 10 months. (You should recognize that all of these limits are "fuzzy" in the sense that there is not a meaningful difference between 4900 gallons at Plant A and 5000 gallons at Sister Plant B.)
50.	Mike Hess Millstone Point (8/24/2006)	Section 5.4.2.3.b	Eliminate the words "decreasing or". The action is in response to an increase in leakage.	Comment accepted. Deleted "decreasing or"
51.	Bruce Bauer Palisades (8/24/2006)	Section 4	Definition of Unidentified leakage is specified as inside of containment. The fact that it is unidentified means it is somewhere in the PCS or any interconnecting systems that you have not been able to locate. Recommend removing the words "inside of containment".	No change. Leakage outside containment (Non-RCPB Leakage) is neither identified not unidentified leakage. (See comment #7, 13 and 15 for previous discussion).
52.	Bruce Bauer Palisades (8/24/2006)	Section 4	Definitions: Statistically Significant Result – change out the & with "and"	Comment accepted and incorporated as suggested.
53.	Bruce Bauer Palisades (8/24/2006)	Section 4	T average (Tave) is that the average of (the average of Thots + average of Tcolds)/2. Could leave as is and let the individual plants use their own methods	The current definition is satisfactory. No change.

| 54. | Bruce Bauer
Palisades
(8/24/2006) | General | Overall the project has become very complex. It appears to have become a "science project". Some how we need to simplify the program. | **We consider most of the "science project" content to be like the "BASES" section of the Technical Specifications.** That is, most of Section 11 is an attempt to explain and quantitatively support the (draft) NRC Appendix D guidelines.

Most of the remaining material is an attempt to provide a quantitative basis and direction for Recommendations which could have been simply stated with <u>no</u> explanation or defense such as:
"The Minimum Level of Detectability must be shown to be ≤ .1 gpm"
"The Utility must screen leak rate values for outliers and ensure that they are removed before updating the baseline mean and standard deviation."
"The Utility must compare the baseline values for the forthcoming quarter to the values for the current quarter and address any differences."

On the other hand, we tried to make the text as readable as possible without overwhelming anyone with too much detail. That is, we hope a typical reader would easily grasp the concepts and more or less believe that we didn't mess up the details. (As part of this effort we tried our best to get an informal review of Section 11 by the appropriate NRC personnel. Since that failed, we asked the resident statistical expert at the Westinghouse Science and Technology Center to review pertinent portions of the two reports. His comments are in Appendix I.) |

55.		Section 5.2.1	Page 22 first full paragraph: What is a daily average value? Do we need to add this to the definitions? Is the paragraph trying to say that if your greater than .15 gpm that you should do another leak rate calculation the next day? The second sentence does not make sense to me.	A daily average value is simply the average of all valid leak rate observations measured on a given calendar day. (Rather than add this to the definitions, we will add it as an (i.e., …) in Section 5.2.1.) Yes, that is what we are trying to say. That is, if you measure a "daily average value" of .15 on Monday and don't perform any measurements on Tuesday, the daily average value for Tuesday will be "missing" and therefore be set to the previous day's value of .15. Therefore you will have two consecutive values of .15 and be in the "Tier Two Action Level" in Section 5.4. We will expand this paragraph and try to clarify it. We will also add a pointer to this comment in that paragraph.
56.	Bruce Bauer Palisades (8/24/2006)	General	I would prefer to have a section that specifies all of the requirements and a separate section(s) that states the basis for the requirements. This would be similar to the layout of TS.	There are no requirements only recommendations. Major recommendations are summarized in the Executive Summary.
57.	Bruce Bauer Palisades (8/24/2006)	General	Negative leak rates can be an indication of in-leakage. We have seen that occur at Palisades and later tracked it down to a valve not being fully seated. There should be some discussion about negative leak rates, especially consistent negative leak rates. If that occurs then an investigation should also occur to determine were the in-leakage is coming from.	Good comment. We will add a comment and pointer to this observation in Section 11.8.
58.	Bruce Bauer Palisades (8/24/2006)	Section 8.2	Numbering scheme is messed up. Have the primary to secondary leak rate values changed. Our values are currently being changed by the NRC.	Comment accepted. Corrected numbering. The Standard Tech spec numbers (NUREG 1431 and 1432) have not changed.
59.	Bruce Bauer Palisades (8/24/2006)	Section 8.2	Eliminate Para 8.2 since each utility has there own TS.	Section 8 is only met to be generic background material, based on standard TS. No change.

60.	Bruce Bauer Palisades (8/24/2006)	Section 8.2	Eliminate Para 8.4.	Section 8 is only met to be generic background material, based on standard TS. No change.
61.	Bruce Bauer Palisades (8/24/2006)	Section 8.2	Eliminate Para 8.5. If feel it is important enough leave the first paragraph and eliminate the remainder of the section. Fill in the reference numbers in the first paragraph.	Section 8 is only met to be generic background material, based on standard TS. No change. Incorporated

Attachment 11.2

Excel Spreadsheet for April 2006 Increase Leakage at Millstone Unit 3

(MP3 April 2006 Leak. xls)

2nd quarter 2006 Unidentified Leakage

CR-06-03610, Approximately 200 DPM from 3-SSR-375-1-2 tubing fitting. 3DGS-SUMP2 in-leakage was 0.04 gpm on 4/7/06, 0.05 on 4/8/06, 0.060 to 0.065 from 4/9/06 to 4/15/06. The leak was isolated 4/15/06 and in-leakage was down to 0.045 on 4/16/06.